419A
DC NULL VOLTMETER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

HP 419A

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the Model 419A DC Null Voltmeter (Figure 1-1). Included are Specifications, Description and Purpose, Instrument Identification, Accessory Equipment Supplied, and Accessory Equipment Available.

1-3. SPECIFICATIONS.

1-4. Table 1-1 contains the specifications for the Model 419A.

1-5. DESCRIPTION AND PURPOSE.

1-6. The Model 419A is housed in a standard -hp- 1/2 module case. A rechargeable battery power supply allows operation independent of ac line. Range and function switching is accomplished by front panel controls.

1-7. The Model 419A provides 18 end scale dc voltage ranges in a 1, 3, 10 sequence from 3 microvolts to 1000 volts. The Model 419A also provides 7 end scale dc current ranges from 30 picoamps to 30 nanoamps. An internal bucking supply allows voltages up to 300 millivolts to be measured with infinite input impedance. The input impedance for the higher ranges is 100 MΩ.

1-8. Recorder output terminals are provided on the rear panel. The voltage available is proportional to the meter deflection and is adjustable from 0 to 1 volt at full scale.

1-9. INSTRUMENT/MANUAL IDENTIFICATION.

1-10. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 419A described in this manual

1-11. ACCESSORY EQUIPMENT SUPPLIED.

1-12. The accessory equipment supplied with each Model 419A is listed and described in Table 1-2.

Table 1-2. Accessory Equipment Supplied

IDENTIFICATION NUMBER	QUANTITY	DESCRIPTION
8120-0078	1	Power Cord
00419-90002	1	Operating and Service Manual

1-13. ACCESSORY EQUIPMENT AVAILABLE.

1-14. The accessory equipment available is listed in Table 1-3. For further information, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

Table 1-3. Accessory Equipment Available

IDENTIFICATION NUMBER	DESCRIPTION
5060-0630	22-Pin Printed Circuit Board Extender
11000A	Dual Banana Plugs to Dual Banana Plugs (44")
11002A	Dual Banana Plugs to Alligator Clips (60")
11003A	Dual Banana Plugs to Probe and Alligator Clip (60")

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 419A DC Null Voltmeter. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Battery Power Supply in the Model 419A can be charged from any source of 115 or 230 volts (±10%), at 50 to 1000 Hz. With the instrument disconnected from the ac power source, move the slide switch (located on the rear panel) until the desired line voltage appears. Power Dissipation is approximately 3 watts.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 419A is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 50°C (122°F).

2-12. BENCH MOUNTING.

2-13. The Model 419A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The Model 419A may be rack mounted by using an Adapter Frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquiries to your -hp- Sales and Service Office. (See Appendix B for office locations.)

2-16. COMBINATION MOUNTING.

2-17. The Model 419A may be mounted in combination with other submodular units by using a Combining Case (-hp- Models 1051A and 1052A). The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

2-18. REPACKAGING FOR SHIPMENT.

2-19. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-20 if the original container is to be used; 2-21 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-20. If original container is to be used, proceed as follows:

a. Place instrument in original container. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

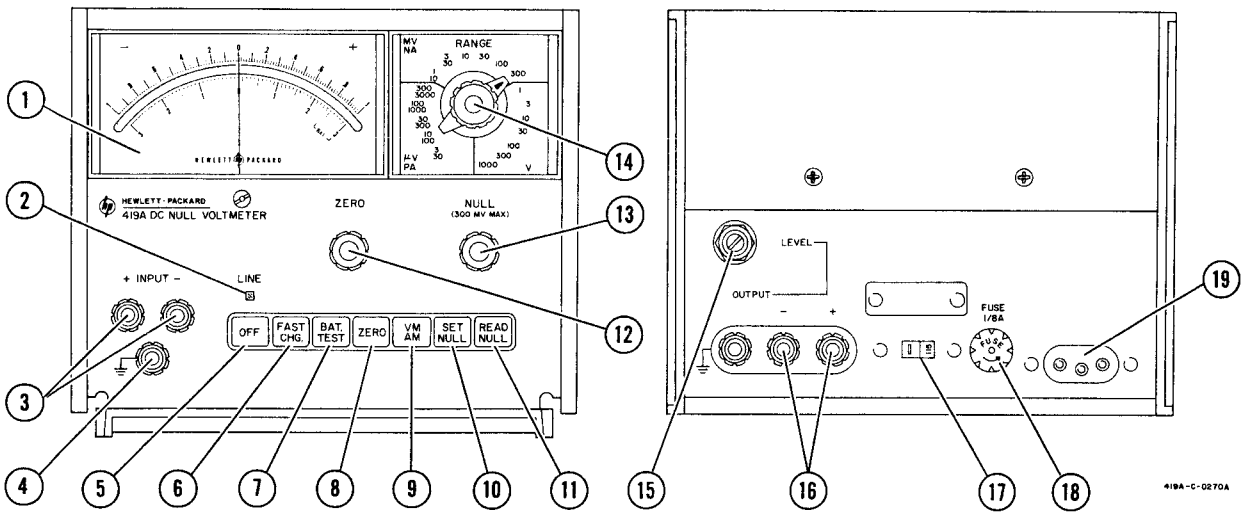
2-21. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT," "FRAGILE" etc.



INDEX NO.	NAME	FUNCTION
1	Meter	Indicates value of applied voltage or current in conjunction with RANGE switch and function pushbuttons.
2	LINE Indicator	Lights to indicate application of ac line voltage to power supply circuits.
3	+ and - INPUT terminals	Accepts leads for application of dc voltage or current input.
4	Ground (⏚) terminal	Accepts lead for grounding of instrument case.
5	OFF	When depressed all functions are turned off.
6	FAST CHG.	When depressed enables batteries to charge at a fast rate.
7	BAT. TEST	When depressed enables meter to indicate battery voltage.
8	ZERO	When depressed internally disconnects voltmeter from + terminal and shorts to - terminal.
9	VM/AM	When depressed enables meter to indicate value of input voltage or current.
10	SET NULL	When depressed places null supply in series opposition to input voltage.
11	READ NULL	When depressed enables meter to indicate value of null supply.
12	ZERO control	Provides continuously variable control of zero offset to ±15 μV.
13	NULL control	Provides continuously variable control for nulling of input voltages below 300 mV when SET NULL pushbutton is depressed.
14	RANGE switch	Selects one of full scale voltage or current ranges.
15	LEVEL control	Provides variable control (0 to ±1 V full scale) of + and - recorder OUTPUT.
16	+ and - OUTPUT terminals	Provide for connection of external recorder.
17	Line Voltage Switch	Enables selection of either 115 or 230 Vac line voltage.
18	FUSE 1/8 A	Accepts fuse for protection of primary power circuits.
19	AC Power Connector	Accepts 3 pin power cord.

Figure 3-1. Front and Rear Panel Controls, Indicators, and Connectors

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Model 419A functions as a dc voltmeter with full (end) scale ranges from 3 μV to 1000 V. An internal bucking supply allows essentially infinite input impedance to be achieved on the 3 μV to 300 mV ranges. The Model 419A can also measure low level dc currents with full (end) scale ranges from 30 pA to 30 nA. This section describes the operating procedures and presents some applications for the Model 419A.

3-3. CONTROLS, INDICATORS AND CONNECTORS.

3-4. Each operating control, indicator and connector located on the Model 419A is identified in Figure 3-1. The description of each component is keyed to the illustration of that component which is included within the figure.

3-5. OPERATING INSTRUCTIONS.

3-6. The Model 419A may be operated on its internal battery power supply or from an ac line. The instrument operates on its internal batteries whenever the ac power cable is removed from the ac power connector. Line operation occurs automatically whenever the power cable is connected to the power connector.

NOTE

Best isolation characteristics and freedom from ground loop problems results when the 419A is operated on its internal battery supply.

3-7. TURN-ON PROCEDURE (BATTERY OPERATION).

NOTE

Disconnect the power cable from the power receptacle for battery operation.

a. Depress BAT. TEST pushbutton; if meter does not indicate within BAT limits, perform battery charging procedure (Paragraph 3-13).

NOTE

When the 419A is received or after a period of storage (especially at high temperatures), the batteries may require changing. Erratic and inaccurate operation may result if the instrument is operated on weak batteries.

b. Set RANGE switch to 1 V.

c. Depress ZERO pushbutton. If meter does not indicate zero, perform the meter zero adjustments (Paragraphs 5-31 thru 5-36).

d. Zero meter on 3 μV range with ZERO control. Periodically recheck setting of ZERO control on the 3 μV range.

3-8. TURN-ON PROCEDURE (AC LINE OPERATION).

a. Set line voltage two-position slide switch (rear panel) to correct position for available line voltage.

CAUTION

DAMAGE TO INSTRUMENT MAY RESULT IF LINE VOLTAGE SWITCH IS SET INCORRECTLY.

b. Connect ac power connector to the line using the ac power cable supplied.

c. Set RANGE switch to 1 V.

d. Depress ZERO pushbutton. If meter does not indicate zero, perform meter zero adjustments (Paragraphs 5-31 thru 5-36).

e. Zero meter on 3 μV range with ZERO control. Periodically recheck setting of zero control on the 3 μV range.

3-9. DC VOLTAGE MEASUREMENTS.

a. Turn on the Model 419A and zero it according to the steps in Paragraph 3-7 (battery operation) or Paragraph 3-8 (AC Line Operation). Allow at least ten minutes warmup time if low voltages (below 1 mV) are to be measured.

b. Connect test leads to + and - INPUT terminals. (See Table 1-3 for a list of test leads available.)

c. Set RANGE switch to range nearest above input voltage. If in doubt, start on the 1000 V range and downrange as necessary.

CAUTION

TO PREVENT DAMAGE TO THE MODEL 419A, DO NOT EXCEED THE FOLLOWING OVERLOAD LIMITS.

RANGE	MAXIMUM INPUT VOLTAGE
3 μV to 3 mV	50 Vdc
10 mV to 300 mV	500 Vdc
1 V to 1000 V	1200 Vdc

d. Connect test leads to voltage to be measured.

CAUTION

DO NOT FLOAT MODEL 419A -INPUT TERMINAL MORE THAN ± 500 VDC FROM GROUND (⏚).

e. Depress VM/AM pushbutton. Read value of input voltage on meter scale.

NOTE

If input voltage is 300 mV or less, infinite input impedance may be obtained by proceeding with steps f thru h.

f. Depress SET NULL pushbutton.

g. Rotate NULL control until meter indicates exactly zero.

NOTE

NULL control gives both coarse and fine adjustment. Rotate control until pointer is slightly down scale from zero; then reverse direction to obtain fine adjustment.

h. Depress READ NULL pushbutton. Read value of input voltage on meter.

3-10. DC CURRENT MEASUREMENTS.

a. Turn on and zero the Model 419A according to the steps in Paragraph 3-7 (Battery Operation) or 3-8 (AC Line Operation). Allow at least ten minutes warmup time if low value currents (below 10 nA) are to be measured.

b. Connect test leads to + and - INPUT terminals.

c. Set RANGE to range nearest above current to be measured. If in doubt, start on 300 nA position and reduce as necessary.

d. Connect test leads in series with current to be measured.

e. Depress VM/AM pushbutton. Read value of input current on meter scale.

3-11. Amplifier Output.

3-12. The rear panel OUTPUT terminals provide a dc voltage which is proportional to meter deflection. The LEVEL control adjusts the maximum value of output voltage. With the LEVEL control turned fully cw, the voltage varies from 0 to ±1 Vdc into a 1 kΩ load. Polarity of the voltage depends upon polarity of the meter deflection.

3-13. Battery Charging Procedure.

3-14. The batteries are automatically trickle charged whenever the Model 419A is connected to an ac powerline and the ZERO, VM/AM, SET NULL or READ NULL pushbutton is depressed. The instrument may be used while trickle charging occurs except when the batteries have been almost completely discharged. Under this condition the Model 419A may not operate properly and the batteries should be at least partially recharged before using the instrument. Generally, 72 hours of trickle charging will restore the batteries to their fully charged state; however, the batteries may be trickle charged indefinitely without damage.

3-15. The batteries may be fast charged by connecting the Model 419A to an ac powerline and depressing the FAST CHG. pushbutton. The instrument cannot be used to make measurements while fast charging the batteries. The batteries should reach full charge in approximately 15 hours.

3-16. To obtain maximum battery life, the following points should be observed.

a. Do not allow the batteries to discharge below the BAT limits on the meter scale.

b. Use fast charge only when necessary.

c. Charge the batteries in moderate temperatures ($80^{\circ}F \pm 10^{\circ}F$, $27^{\circ}C \pm 5.6^{\circ}C$) whenever possible.

d. Do not store the instrument at temperatures above $122^{\circ}F$ ($50^{\circ}C$) or below $-40^{\circ}F$ ($-20^{\circ}C$).

3-17. APPLICATIONS.

3-18. In addition to straightforward dc voltage and current measurements, the Model 419A has a number of applications. Several of these are presented in the following paragraphs.

3-19. Measuring Leakage.

3-20. By using the Model 419A as a sensitive dc ammeter, very high resistance leakage paths in insulating materials can be detected and measured. Leakage is observed by connecting the output of a dc power supply across the insulating material and placing the Model 419A in series with one of the power supply leads. By noting the current flow on the Model 419A, the leakage resistance can be calculated from the formula:

$$R_{(leakage)} = \frac{E_{(power\ supply)}}{I_{(419A)}}$$

Example:

Assume the leakage between 2 points (A and B) in a standards laboratory oil bath is to be measured. A 100 V power supply and the 419A are connected as shown in Figure 3-2.

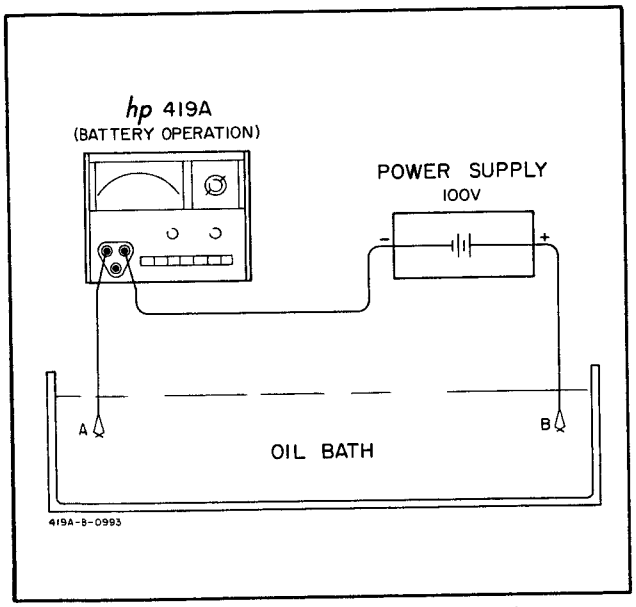


Figure 3-2. Leakage Measurement

Assume the 419A indicates 10 pA. The leakage of the oil can then be calculated.

$$R_{(leakage)} = \frac{E_{(power\ supply)}}{I_{(419A)}}$$

$$R_{(leakage)} = \frac{100\ V}{10\ pA}$$

$$R_{(leakage)} = 10^{13}\ \Omega$$

$$R_{(leakage)} = 10^{7}\ M\Omega$$

3-21. Calibrating A Voltage Source.

3-22. The Model 419A can serve as a very sensitive and accurate null detector. These features can be especially useful when matching the output of an adjustable voltage source to a reference standard. The adjustable voltage source and the reference standard are connected in series opposition with the Model 419A in series with one of the leads. The adjustable voltage source is then adjusted for a null indication on the Model 419A.

Example:

Assume the output of a dc standard (-hp- Model 741B) is to be matched to the output of a 1 V transfer standard (-hp- Model 735A). These instruments and the Model 419A are connected as shown in Figure 3-3.

The reference standard and the adjustable voltage source are both set for a 1 V output. The Model 419A indicates any deviations between the two outputs. By making internal adjustments affecting the output of the voltage source until null is reached on the Model 419A's 3 μV range, the output of the adjustable voltage source is very accurately matched to the reference standard.

3-23. Measuring and Recording Drift.

3-24. The rear panel OUTPUT terminals provide a dc voltage (0 to ± 1 V) proportional to meter deflection. This output can be used to record the drift of a dc voltage source when that source is compared to a very stable reference voltage.

Example:

Assume that the drift of a 10 V power supply is to be observed and recorded. The power supply, Model 419A, stable voltage source (-hp- Model 740B) and a strip chart recorder (-hp- Sanborn Model 7701A) are connected as shown in Figure 3-4.

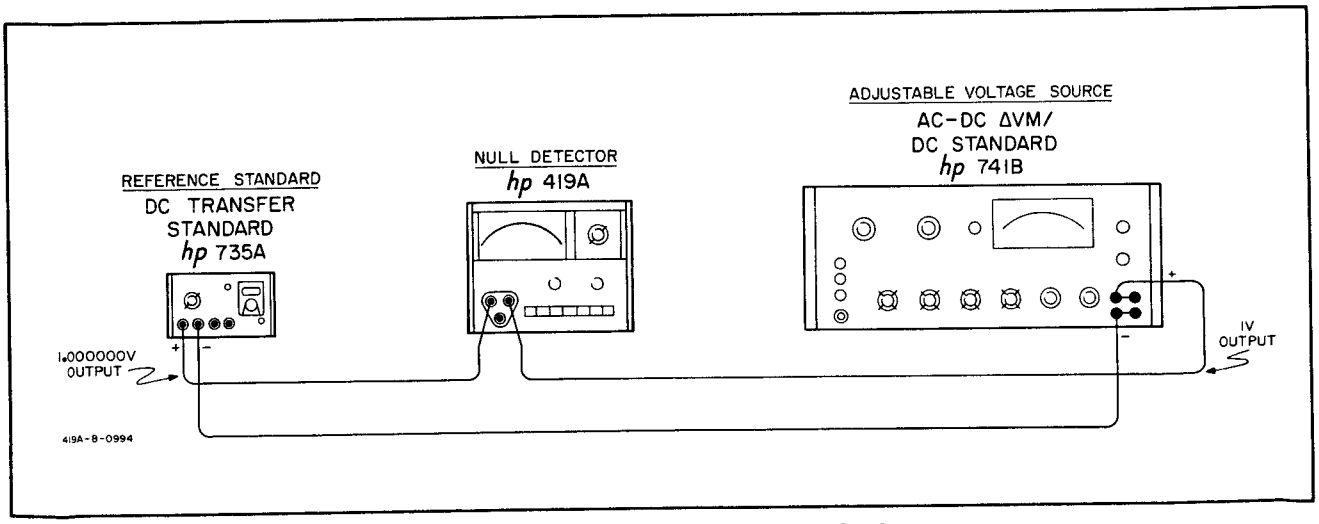


Figure 3-3. Calibrating A DC Standard

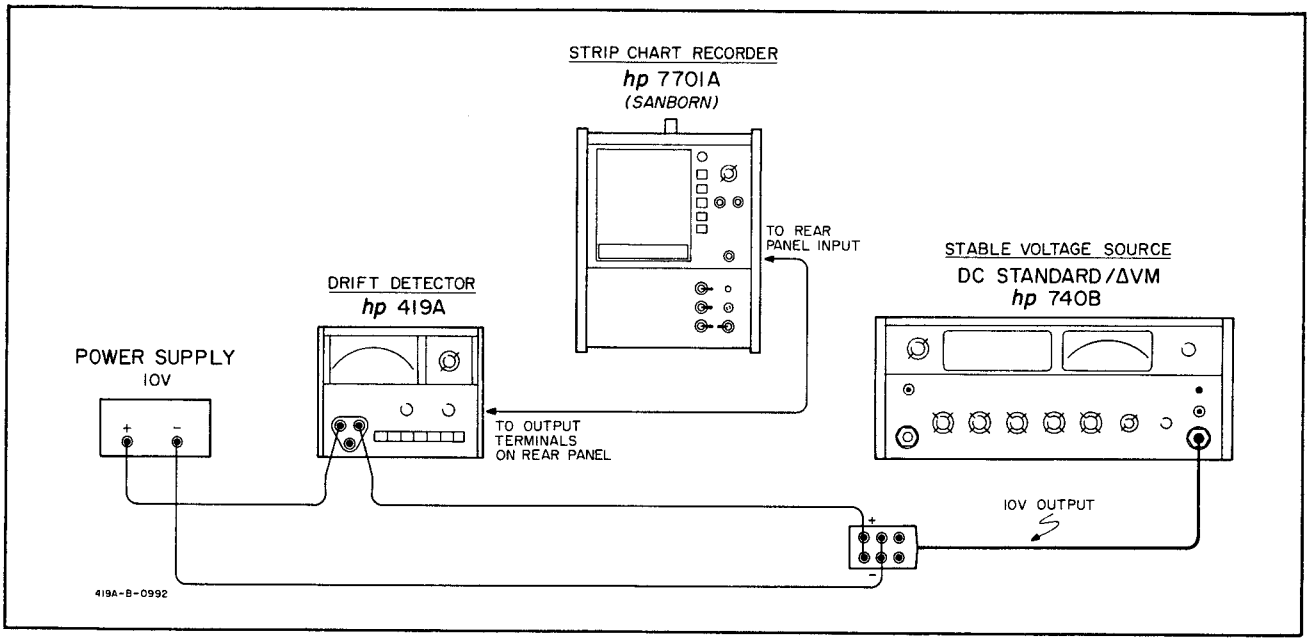


Figure 3-4. Measuring Power Supply Drift

The output of the stable voltage source or the power supply is adjusted until the Model 419A indicates null. The voltage range used on the Model 419A depends on how much drift is anticipated from the power supply. If the power supply output drifts 8 mV over a period of time, the Model 419A will indicate this variation (on the 10 mV range) and supply the strip chart recorder with a voltage that changes from 0 to 0.8 V over the same period. In this case, the drift is amplified by a factor of 100. Gains as high as 333,000 (on the 3 μV range) are available when the Model 419A is used on the lower ranges.

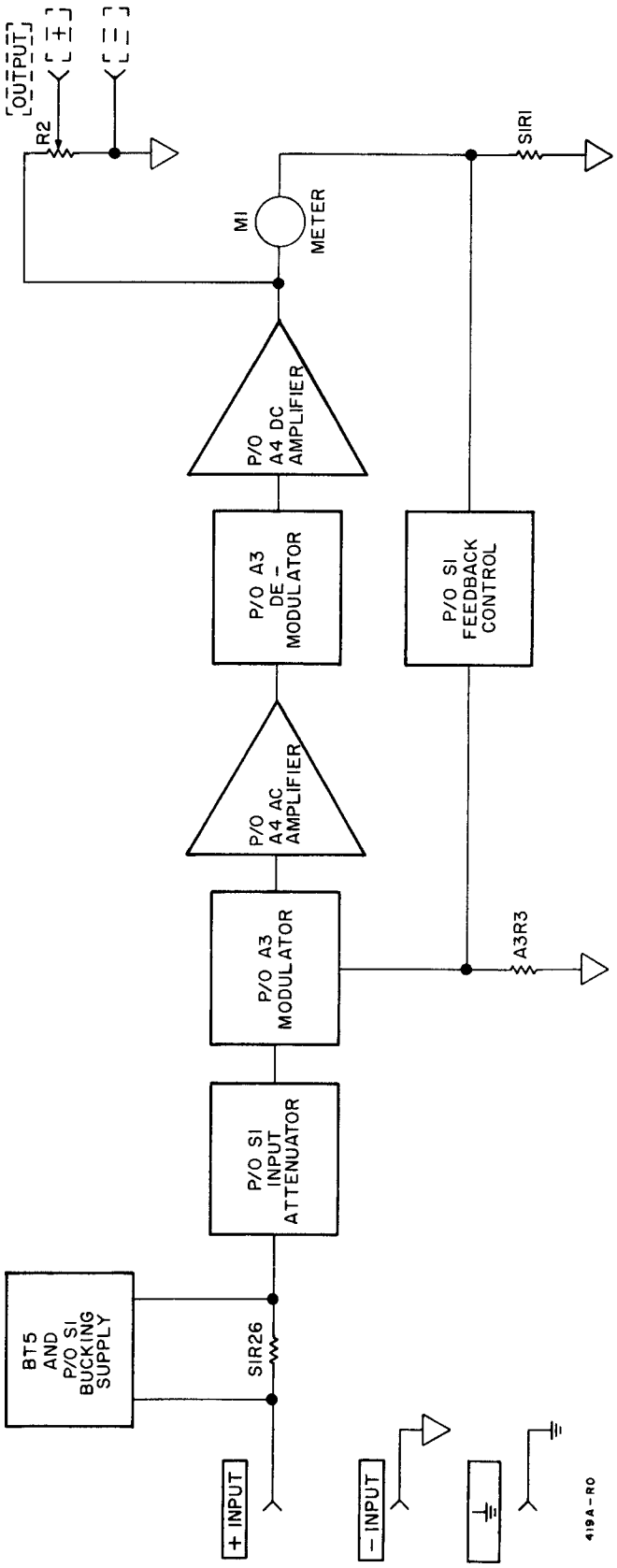


Figure 4-1. Model 419A Block Diagram

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains the theory of operation of the Model 419A DC Null Voltmeter.

4-3. GENERAL DESCRIPTION.

4-4. The Model 419A functions as a dc voltmeter, a dc null voltmeter and a dc ammeter. When used as a dc voltmeter, the Model 419A provides end scale ranges from 3 μV to 1000 V with an input resistance of 100 kΩ to 100 MΩ, depending on the range selected. When used as a dc null voltmeter, end scale ranges from 3 μV to 300 mV are provided with infinite input resistance. End scale ranges from 30 pA to 30 nA are provided in the ammeter function with a constant 100 kΩ input resistance.

4-5. When used as an ammeter, circuit operation is identical to the voltmeter mode of operation. Current values are derived from the voltage drop across the constant 100 kΩ input resistance on the 30 pA (3 μV) to 30 nA (3 mV) ranges.

4-6. A dc voltage being measured with the Model 419A is applied to the Input Attenuator through the + and - INPUT terminals, located on the front panel. In the dc voltmeter and ammeter modes, the input is applied to the input attenuator through S1R26. In the dc null voltmeter mode, the output of the Bucking Supply is applied to S1R26 in series opposition to the input dc voltage. The difference between the Bucking Supply output and the input dc voltage is applied to the Input Attenuator. Table 4-1 lists the attenuation factors provided by the Input Attenuator for all ranges.

4-7. The dc output of the Input Attenuator is modulated by the Modulator. The Modulator is comprised of two photocells which are alternately illuminated by two neon lamps. The output of the modulator is a square wave whose amplitude is proportional to the difference between the amplitudes of the input dc voltage and the feedback.

4-8. The square wave output of the modulator is amplified by the AC Amplifier. The AC Amplifier is a six-stage, high gain amplifier. Its output is applied to the Demodulator. The Demodulator output is a dc level whose amplitude is proportional to the amplitude of the square wave. The Demodulator output is applied to the DC Amplifier, a three-stage voltage and power amplifier.

4-9. The forward gain provided by the AC and DC Amplifiers for each range is listed in Table 4-1. The output of the DC Amplifier (approximately 1 Vdc for end scale meter deflection) is applied to M1 and is also available at the OUTPUT + and - terminals.

4-10. The Feedback Control circuit is ganged to the Input Attenuator by the RANGE switch S1. The feedback provided by the Feedback Control circuit is listed in Table 4-1. Algebraic addition of attenuation factor, forward gain and feedback gives the closed loop gain. The closed loop gain provides 18 end scale ranges in 10 dB steps.

4-11. DETAILED DESCRIPTION.

4-12. BUCKING SUPPLY (See Figure 6-3).

4-13. Dc input voltages up to 200 mV may be measured in either the dc voltmeter mode or the null voltmeter

Table 4-1. Model 419A Attenuation and Gain Characteristics

RANGE	ATTENUATION FACTOR	FORWARD GAIN	FEEDBACK	CLOSED LOOP GAIN
3 μV/ 30 pA	0 dB	+150 dB	-40 dB	+110 dB
10 μV/ 100 pA	0 dB	+150 dB	-50 dB	+100 dB
30 μV/ 300 pA	0 dB	+150 dB	-60 dB	+ 90 dB
100 μV/1000 pA	0 dB	+150 dB	-70 dB	+ 80 dB
300 μV/3000 pA	0 dB	+130 dB	-60 dB	+ 70 dB
1 mV/ 10 nA	0 dB	+130 dB	-70 dB	+ 60 dB
3 mV/ 30 nA	0 dB	+120 dB	-70 dB	+ 50 dB
10 mV	- 20 dB	+120 dB	-60 dB	+ 40 dB
30 mV	- 20 dB	+120 dB	-70 dB	+ 30 dB
100 mV	- 40 dB	+120 dB	-60 dB	+ 20 dB
300 mV	- 40 dB	+120 dB	-70 dB	+ 10 dB
1 V	- 60 dB	+120 dB	-60 dB	0 dB
3 V	- 60 dB	+120 dB	-70 dB	- 10 dB
10 V	- 80 dB	+120 dB	-60 dB	- 20 dB
30 V	- 80 dB	+120 dB	-70 dB	- 30 dB
100 V	-100 dB	+120 dB	-60 dB	- 40 dB
300 V	-100 dB	+120 dB	-70 dB	- 50 dB
1000 V	-120 dB	+120 dB	-60 dB	- 60 dB

mode. In the dc voltmeter mode, the input voltage is applied to the Input Attenuator through the + and - INPUT terminals and through S1R26. In the null voltmeter mode, the input is applied in the same manner, but is opposed by the bucking voltage applied to S1R26.

4-14. When the SET NULL Pushbutton is depressed, the BT5 voltage is applied through R4 and R5 and the voltage divider network (S1R1 thru S1R11) to S1R26. The difference between the input voltage and the bucking voltage is indicated on the Meter M1. The bucking voltage is then adjusted through the use of course and fine NULL controls (R4 and R5) until a null is indicated on the Meter. When the READ NULL Pushbutton is depressed, the input voltage is disconnected and the polarity of the bucking voltage is reversed. The value of the bucking voltage (equal to input voltage) is indicated on the Meter M1.

4-15. INPUT ATTENUATOR.

4-16. All voltages and currents to be measured are applied to the input attenuator, which is a resistive divider consisting of S1R20 to S1R25 and R3. The attenuation factor depends upon the position of the RANGE switch. The attenuator is divided into two separate networks to provide the proper impedance levels for filter capacitors A3C2 and A3C3. (Table 4-1 lists the attenuation factors for all ranges.)

4-17. INPUT FILTER.

4-18. L1 and L2, and A3C2 and A3C3 filter superimposed ac noise from the input signal.

4-19. MODULATOR/DEMODULATOR.

4-20. The modulator/demodulator is a photo-conductive chopper. It consists of a neon oscillator with two neon bulbs and four photocells mounted in one assembly. The photocells have an extremely high resistance when not illuminated, and a very low resistance when illuminated.

4-21. Assume that A3V1 is illuminated and A3V2 is not. The resistance of A3V2 will be many times greater than the resistance of A3V1. The voltage across A3V2 (input voltage) will be applied through A3C4 to the base of Q1. The oscillator will then switch off the bulb illuminating A3V1, and switch on a bulb which illuminates A3V2. A3V1 now has the greatest resistance, and A3V2 is a virtual short to the feedback which is coupled to Q1. The modulator provides a square wave output proportional to the difference between the dc input and dc feedback signals. The square wave frequency will depend upon the switching frequency of the neon oscillator.

4-22. The demodulator is operated by the neon oscillator in the same manner. It provides a dc output proportional to the amplitude of the square wave input.

4-23. AC AMPLIFIER.

4-24. Amplification of the square wave output from the modulator is provided by a six stage direct-coupled amplifier. Dc feedback from the base of Q4 to the base of Q1 provides bias stabilization. Ac feedback from the emitter of Q3 to the emitter of Q1 is used to vary the gain of Q1 thru Q3. This is accomplished by varying the amount of feedback to Q1, due to the position of the RANGE Switch. In the 3 μV to 1 mV range, resistor R7 is shorted out, decreasing the negative feedback applied to Q1.

4-25. Feedback from the emitters of Q6 and Q7 is also controlled to vary the gain of Q4 thru Q7. In the 3 μV to 100 μV range resistor R16 is shorted out, decreasing the negative feedback applied to Q4. Capacitors A3C4 and A4C9 couple the ac input and output and block the dc bias voltages.

4-26. DC AMPLIFIER.

4-27. The output of the demodulator is applied to a four stage voltage and power amplifier. Q9 provides temperature compensation for the circuit. When Q8 and Q9 increase conduction due to a rise in temperature, the emitter to base voltage of Q4 decreases, which decreases the Q8 forward bias. This maintains Q8 conduction at a constant level.

4-28. The final stage of amplification is a complimentary symmetry amplifier consisting of Q12, Q13, CR13 and CR14. The diodes bias the transistors at a constant idling state, with no input signal applied. When an input is applied, the transistor responds immediately with an output. The input does not have to reach a certain amplitude to cause conduction in the transistors, since they are already at an idling condition.

4-29. The output of the dc amplifier will be 1 V for end scale input on all ranges. An output is also applied to the + and - OUTPUT terminals J5 and J6. Adjustable resistor R2 provides control of the recorder output from 0 to ±1 volt end scale. Diode network CR5 to CR12 protects the amplifier circuit from an overload.

4-30. METER CIRCUIT.

4-31. The meter is a current driven device which utilizes a taut band movement. A 1 volt output of the dc amplifier provides end scale needle deflection on all ranges. During FAST CHARGE and off (positions 1 and 2 of Function Switch S2), the meter is protected from transient voltages by a short across it. During the BATTERY TEST mode (position 3 of Function Switch S2), resistor S2R1 provides the amplifier load, because the meter is disconnected from the amplifier circuit.

4-32. Resistors R41 to R44 provide for calibration of the meter. The resistors are connected in parallel with the meter as a function of the RANGE switch setting.

4-33. FEEDBACK CONTROL.

4-34. Control of feedback is accomplished through a deck of the RANGE switch. The amount of feedback depends upon the position of the RANGE switch. The closed loop gain of the amplifier may be determined by subtracting the feedback from the forward gain. The feedback provided for each range is listed in Table 4-1.

4-35. POWER SUPPLY AND NEON DRIVER (Figure 6-4).

4-36. The power source for the 419A is four rechargeable batteries, which supply a +13 V and a -13 V output. The 419A may also be operated from line voltage, which will trickle-charge the batteries during operation.

4-37. The line input may be either 115 V or 230 V from 50 to 1000 Hz. The input is rectified by CR1 thru CR4 and applied to series regulator Q1.

4-38. Zener diode CR5 supplies a constant reference to the base of Q1. The emitter of Q1 is referenced to the voltage across R2 or R3. If the output current increases, Q1 will conduct less, due to less emitter to base bias. This will decrease the output current. If either output decreases, Q1 will conduct harder, increasing the output current.

4-39. The neon driver consists of a series regulator circuit, a blocking oscillator, and a neon circuit. Transistor Q5 and zener diode CR9 provide a constant reference to series regulator Q4. The frequency of the blocking oscillator is controlled by varying the voltage across C3. This is accomplished through adjustable resistor R9, which controls the bias on the base of Q4.

4-40. Due to inherent characteristics, either Q2 or Q3 will conduct harder when power is applied. Assume that Q2 conducts more than Q3. As Q2 conducts, a negative going signal is coupled through T2 to the base of Q3. This causes Q3 to cut off completely. At the same time, a positive going signal is coupled to the base of Q2, causing it to conduct more. While Q2 is conducting, a negative output will be coupled to the neon circuit.

4-41. When T2 becomes saturated, the positive signal is removed from the base of Q2, and it cuts off. At the same time, the negative signal is removed from the base of Q3, allowing it to start conducting. As Q3 conducts, a negative going signal is applied to the base of Q2, holding it cut off, and a positive going signal is applied to the base of Q3. Q3 continues to conduct, causing a positive output to be coupled to the neon circuit. This will continue until T2 becomes saturated, and starts the cycle over again.

4-42. The output of the oscillator is coupled through T2 to the neon circuit. When an input is applied to the circuit, due to inherent resistance characteristics, either DS1 or DS2 will light, depending upon which has the least resistance.

4-43. Assume that DS1 lights when the input is applied to T2. Capacitor C1 charges until the oscillator switches the input, and DS1 goes off. When the oscillator switches again, the charge on C1 insures that DS2 fires, and DS1 stays off. This cycle continues with DS1 and the DS2 firing, as long as there is an output from the oscillator. CR1 and CR2 prevent the capacitor from discharging through R1 and R2.

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
Voltmeter Calibrator	DC Voltage Range: 0.3 mV to 300 V Accuracy: ±0.2%	-hp- Model 738BR Voltmeter Calibrator
Strip Chart Recorder	Voltage Range: 1 Vdc Speed: 50 mm/sec Frequency Response: 5 Hz	Sanborn Model 7701A Strip Chart Recorder
Oscillator	Output Freq: 60 Hz Output Voltage: 0.5 V rms	-hp- Model 208A Oscillator
Oscilloscope	Horizontal Sensitivity: 2 ms/cm Vertical Sensitivity: 50 mV/cm Frequency Response: 100 kHz	-hp- Model 130C Oscilloscope
Electronic Counter	Counting Range: 300 to 400 pps Accuracy: ±1 count	-hp- Model 5211A Electronic Counter
DC Voltmeter	Voltage Range: 30 Vdc Accuracy: ±2%	-hp- Model 427A Voltmeter
Capacitor	0.1 μF ±20% 10 Vac	-hp- Part No. 0170-0085
Resistors	100 Ω ±0.1% 1/8 W ww 600 Ω ±1% 1/8 W comp 10 kΩ ±0.25% 1/8 W met flm 100 kΩ ±0.25% 1/8 W met flm 900 kΩ ±0.5% 1/2 W met flm 1 MΩ ±0.1% 1/8 W ww 9 MΩ ±0.5% 1/2 W met flm	-hp- Part No. 0811-0398 -hp- Part No. 0684-1031 -hp- Part No. 0698-3193 -hp- Part No. 0698-4057 -hp- Part No. 0698-5488 -hp- Part No. 0811-0473 -hp- Part No. 0698-5443

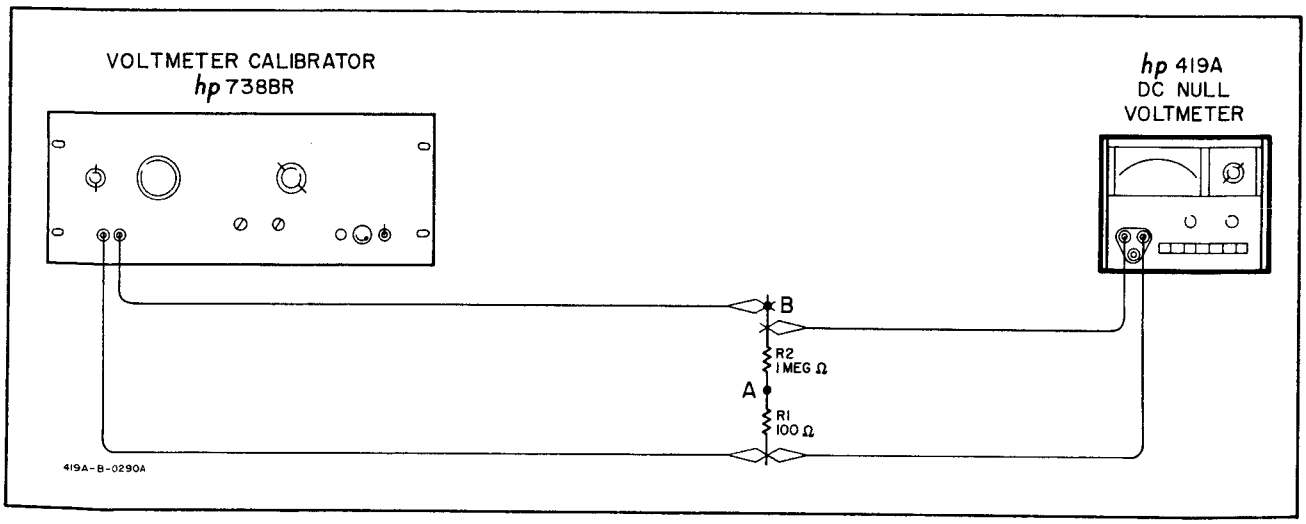


Figure 5-1. Voltmeter Accuracy Performance Test Setup

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains the information necessary for maintenance of the Model 419A DC Null Voltmeter. Included are performance tests, repair procedures, adjustment and calibration procedures, and trouble-shooting procedures.

5-3. TEST EQUIPMENT.

5-4. The test equipment required for maintenance of the Model 419A is listed in Table 5-1. Equipment having similar characteristics may be substituted for the equipment listed.

5-5. PERFORMANCE TESTS.

5-6. The performance tests presented in this section are front-panel procedures designed to compare the Model 419A with its published specifications (Table 1-1). These tests may be incorporated in periodic maintenance, post repair, and incoming quality control inspection. These tests should be conducted before any attempt is made at instrument calibration.

5-7. VOLTMETER ACCURACY TEST.

5-8. The voltmeter accuracy performance test setup is illustrated in Figure 5-1. A voltmeter calibrator (-hp- Model 738BR), a 100 Ω resistor (-hp- Part No. 0811-0398), and a 1 MΩ resistor (-hp- Part No. 0811-0473) are required for this test.

a. Connect test setup illustrated in Figure 5-1.

b. Make control settings indicated in step 1 of Table 5-2; if Model 419A reading is not within tolerances listed, perform Full Scale Calibration procedure (Paragraph 5-37).

c. Repeat step b for remaining steps in Table 5-2.

5-9. BUCKING VOLTAGE TEST.

5-10. No external test equipment is required for the bucking voltage performance test.

a. Depress 419A READ NULL pushbutton; set RANGE to 300 mV.

b. Rotate NULL control fully clockwise and then fully counterclockwise; if 419A meter does not peg in negative and positive direction, respectively, replace BT5.

Table 5-2. Accuracy Performance Test, Supplemental Data

STEP	VOLTMETER CALIBRATOR DC OUTPUT	POINT OF MEASUREMENT FIGURE 5-1		419A RANGE	419A READING
1	30 mV	A		3 μV	2.84 to 3.16
2	100 mV	A		10 μV	9.7 to 10.3
3	300 mV	A		30 μV	29.3 to 30.7
4	1.0 V	A		100 μV	97.9 to 102.1
5	0.3 mV	B		300 μV	293.9 to 306.1
6	1 mV	B		1 mV	0.98 to 1.02
7	3 mV	B		3 mV	2.94 to 3.06
8	10 mV	B		10 mV	9.8 to 10.2
9	30 mV	B		30 mV	29.4 to 30.6
10	100 mV	B	Remove Attenuator	100 mV	98 to 102
11	300 mV	B		300 mV	294 to 306
12	1 V	B		1 V	0.98 to 1.02
13	3 V	B		3 V	2.94 to 3.06
14	10 V	B		10 V	9.8 to 10.2
15	30 V	B		30 V	29.4 to 30.6
16	100 V	B		100 V	98 to 102
17	300 V	B		300 V	294 to 306
18	300 V	B		1000 V	280 to 320

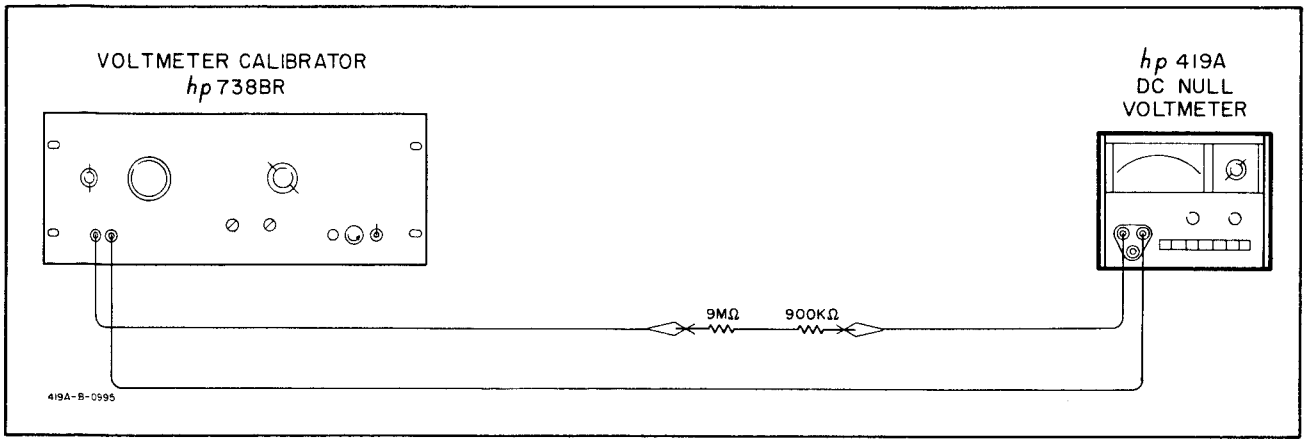


Figure 5-2. Ammeter Accuracy Test Setup

5-11. AMMETER ACCURACY TEST.

5-12. The ammeter accuracy performance test is illustrated in Figure 5-2. A voltmeter calibrator (-hp- Model 738BR), a 9 MΩ resistor (-hp- Part No. 0698-5443) and a 900 kΩ resistor (-hp- Part No. 0698-5488) are required for this test.

a. Connect test setup illustrated in Figure 5-2.

b. Set Model 419A and voltmeter calibrator controls as indicated in step 1 of Table 5-3. If Model 419A reading is not within the listed tolerances, troubleshoot the input attenuator (Paragraph 5-49).

Table 5-3. Ammeter Accuracy Test

STEP	VOLTMETER CALIBRATOR DC OUTPUT	419A RANGE	419A READING
1	.3 mV	30 pA	28.1 to 31.9
2	.001 V	100 pA	96 to 104
3	.003 V	300 pA	290 to 310
4	.01 V	1000 pA	970 to 1030
5	.03 V	3000 pA	2910 to 3090
6	.1 V	10 nA	9.7 to 10.3
7	.3 V	30 nA	29.1 to 30.9

5-13. RESPONSE TIME TEST.

5-14. A strip chart recorder (Sanborn Model 7701A), a voltmeter calibrator (-hp- Model 738BR), a 100 Ω resistor (-hp- Part No. 0811-0398), and a 1 MΩ resistor (-hp- Part No. 0811-0473) are required for this test.

a. Connect strip chart recorder to 419A + and - OUTPUT terminals.

b. Construct test setup illustrated in Figure 5-1; turn voltmeter calibrator dc output off and set for 30 mV output; connect 419A + INPUT terminal to Point A.

c. Set 419A RANGE switch to 3 μV position; depress VM/AM pushbutton.

d. Start strip chart recorder and turn voltmeter calibrator dc output on; if strip chart recorder does not show OUTPUT at 95% between 2 and 3 seconds, perform Chopper Adjustment (Paragraph 5-33).

e. Turn voltmeter calibrator dc output off and set for 100 mV output; set 419A RANGE switch to 10 μV position.

f. Start strip chart recorder and turn voltmeter calibrator dc output on; if strip chart recorder does not show OUTPUT at 95% within 1 second, perform Chopper Adjustment (Paragraph 5-33).

5-15. SUPERIMPOSED AC REJECTION TEST.

5-16. The superimposed ac rejection test setup is illustrated in Figure 5-3. An oscillator (-hp- Model 208A), a 600 Ω resistor (-hp- Part No. 0727-0081), a 10 kΩ resistor (-hp- Part No. 0684-1031), and a 0.1 μF capacitor (-hp- Part No. 0170-0085) are required for this test.

a. Connect test setup illustrated in Figure 5-3; do not connect oscillator.

b. Depress 419A SET NULL pushbutton; set NULL control for +9 μV on 10 μV range.

c. Connect oscillator and set its output frequency for 60 Hz; output voltage for 0.5 volts rms. Model 419A reading should not vary more than ±0.2 μV after the initial transient.

5-17. NOISE TEST.

5-18. No external test equipment is required for the noise test.

a. Short 419A + and - INPUT terminals.

b. Zero 419A in VM function on 3 μV RANGE.

c. If noise displayed on 419A meter exceeds 0.3 μV p-p, perform Chopper Adjustment (Paragraph 5-33).

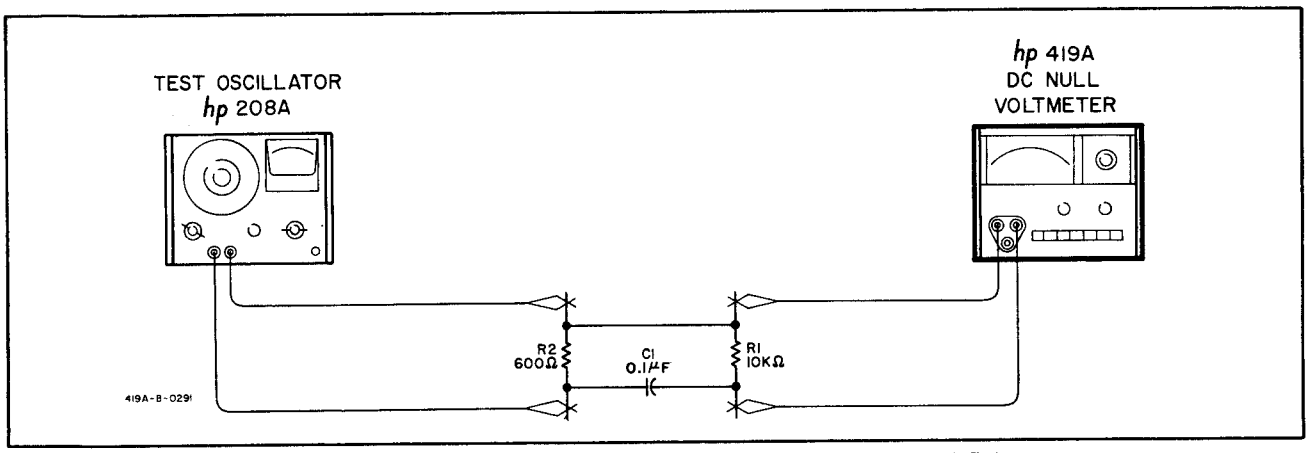


Figure 5-3. Superimposed AC Rejection Performance Test Setup

5-19. INPUT RESISTANCE TEST.

5-20. A Voltmeter Calibrator (-hp- Model 738BR), a 10 kΩ resistor (-hp- Part No. 0698-3193), a 100 kΩ resistor (-hp- Part No. 0698-4057), a 1 MΩ resistor (-hp- Part No. 0757-1054) and a 10 MΩ resistor (-hp- Part No. 0698-4128) are required for this test.

a. Connect a 10 kΩ resistor to Model 419A + INPUT terminal.

b. Connect voltmeter calibrator dc output terminals to 10 kΩ resistor and -INPUT terminal on the Model 419A.

c. Set Model 419A RANGE to 3 mV; set voltmeter calibrator output to 3 mV (.003 V).

d. The Model 419A should indicate 2.73 mV which verifies an input resistance of 100 kΩ on the 3 mV range, as given by the following formula:

$$R_{in} = \frac{R_s \times E_m}{E_o - E_m}$$

where R_{in} is the 419A input resistance, R_s is the series resistance, E_m is the voltage indicated on the Model 419A meter and E_o is the voltmeter calibrator output voltage.

NOTE

The input resistance may vary slightly and a tolerance of ±3% should be allowed.

e. Replace the 10 kΩ resistor with a 100 kΩ resistor.

f. Set Model 419A RANGE to 10 mV; set voltmeter calibrator output to 10 mV (.01 V).

g. Model 419A should read 9.09 mV which verifies an input resistance of 1 MΩ on the 10 mV range.

h. Replace the 100 kΩ resistor with a 1 MΩ resistor.

i. Set Model 419A RANGE to 100 mV; set voltmeter calibrator output to 100 mV (.1 V).

j. Model 419A should read 90.9 mV which verifies an input resistance of 10 MΩ on the 100 mV range.

k. Replace the 1 MΩ resistor with a 10 MΩ resistor.

l. Set Model 419A RANGE to 1 V; set voltmeter calibrator output to 1 V.

m. Model 419A should read 0.909 V which verifies an input resistance of 100 MΩ on the 1 V range.

5-21. REPAIR PROCEDURES.

5-22. COVER REMOVAL.

5-23. When it is necessary to repair or adjust the Model 419A, one or more covers will have to be removed. Refer to the following steps for cover removal procedure.

a. TOP COVER. Remove top cover screws; slide cover to rear and lift to remove.

b. SIDE COVERS. Remove four screws from side cover; lift to remove.

c. BOTTOM COVER. Remove bottom cover screws at rear of cover. Slide cover to rear and remove.

5-24. SERVICING PRINTED CIRCUIT BOARDS.

5-25. The Model 419A has two etched circuit boards. Use caution when removing to avoid damaging mounted components. The assembly and -hp- part number are etched on the interior of the circuit board to identify them. Refer to Section VII for parts replacement and -hp- part number information.

5-26. The etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

a. To avoid contamination, wear clean lint-free cotton or rubber gloves.

b. Use a low-heat (25 to 50 watts) small-tip soldering iron and a small diameter rosin core solder.

c. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate or cause damage to the component.

d. Component lead hole should be cleaned before inserting new lead.

e. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

f. Clean excess flux from the connection and adjoining area.

g. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

5-27. INSTALLATION OF REPLACEMENT NEON SUBASSEMBLY (-hp- Part No. 1990-0214).

5-28. Physical alignment and neon selection are critical. When trouble is isolated to the neon subassembly, the complete subassembly should be changed rather than replacing the defective neons.

a. Remove the top and side cover on the meter side of the instrument.

b. Disconnect the neon subassembly leads from pins on A2 board. (Note location for reconnecting the new leads). Maneuver subassembly cable through the grommet on the inner shield.

c. Remove the two photochopper assembly mounting screws and remove neon subassembly.

d. Install new neon subassembly. Note that the rubber grommet on the subassembly is offset toward the top of the instrument.

e. Route the neon subassembly cable through the inner shield and reconnect the cable to the A2 board.

f. Replace the side cover and recalibrate the Model 419A as outlined in Paragraph 5-29.

5-29. ADJUSTMENT AND CALIBRATION.

5-30. The following is a complete adjustment and calibration procedure for the Model 419A. These procedures should be conducted only if it has been previously established by Performance Tests (Paragraphs 5-5 to 5-20) that the Model 419A is out of adjustment.

5-31. MECHANICAL ZERO ADJUSTMENT.

5-32. The mechanical zero adjustment is located on the instrument front panel. If the meter pointer does not indicate zero when the instrument power has been off for at least one minute, mechanically zero the meter following the procedure outlined below.

a. Turn instrument power off; disconnect input signal; remove output cable; and allow one minute for meter pointer to stabilize.

b. Rotate zero adjustment CW until pointer is to left of zero, moving upscale. Continue until pointer is at zero. If pointer overshoots zero, repeat operation.

c. When the pointer is exactly at zero, rotate zero adjustment slightly CCW to free it. If the meter pointer moves to the left during this step, repeat steps b and c.

5-33. CHOPPER ADJUSTMENT.

5-34. An Oscilloscope (-hp- Model 130C) and an Electronic Counter (-hp- Model 5211A) are required for the chopper adjustment.

NOTE

If Serial Prefix of instrument is 514-, refer to Appendix C for chopper adjustment information.

a. Remove 419A top cover and shield.

b. Connect Oscilloscope and Electronic Counter to A2TP2.

c. Set Oscilloscope for 2 ms/cm horizontal sensitivity and 50 mV/cm vertical sensitivity.

d. Adjust A2R9 (FREQ.) for Electronic Counter indication of 320 to 340. (This corresponds to chopper rate of 160-170 pps as Electronic Counter also counts smaller pulses.) Adjust A2R5 (NEON CURRENT) for waveform amplitude of 140 to 160 mV. Figure 5-4 shows the chopper waveform.

NOTE

If the Neon Waveform is unstable, an intermittent neon bulb is indicated. See Paragraph 5-27 for replacement information.

e. If correct waveform is obtained and response time is still not within limits of Paragraph 5-13, A4R26 will have to be reselected. If response on 3 μV range is longer than 3 seconds, the value of A4R26 should be decreased. If response on 3 μV range is less than 2 seconds,

A4R26 should be increased. A4R26 should be between 6.8 kΩ and 15 kΩ with a typical value of 10 kΩ. A4R26 is an Allen-Bradley, composition, 1/4 watt ±10%, resistor.

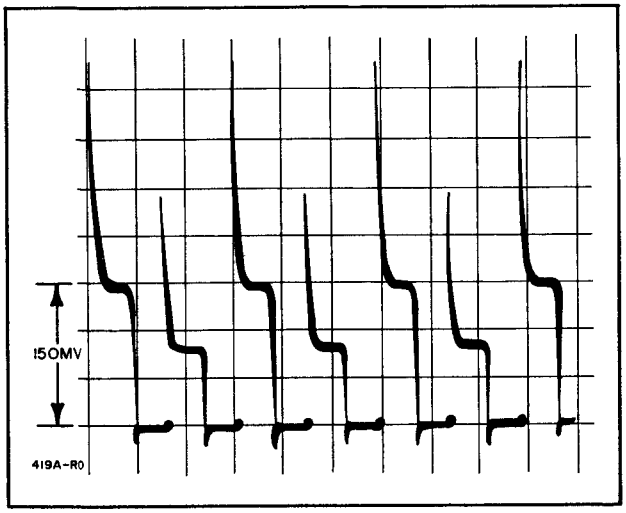


Figure 5-4. Neon Drive Waveform (A2TP2)

5-35. ELECTRICAL ZERO ADJUSTMENT.

5-36. The electrical zero adjustment should be performed when the meter pointer does not indicate zero on the 1 volt range when instrument power has been on for at least one minute. No external equipment is required for this adjustment.

a. Set 419A controls as follows:
RANGE . . . . . 1 V
ZERO pushbutton . . . . . Depressed

b. Remove top cover; adjust A4R14 (1 V ZERO for zero deflection on 419A meter.

5-37. FULL SCALE CALIBRATION.

5-38. The full scale calibration consists of performing the 3 μV, 10 μV, 1 mV, and 1 V adjustments. A Voltmeter Calibrator (-hp- Model 738BR), a 100 Ω Resistor (-hp- Part No. 0811-0398) and a 1 MΩ Resistor (-hp- Part No. 0811-0473) are required for this test.

a. Connect test setup illustrated in Figure 5-1.

b. Remove 419A top cover; depress VM/AM pushbutton.

c. Set Voltmeter Calibrator for 30 mV output; connect 419A to Point A; adjust A4R41 (3 μV) for full scale deflection on 3 μV range.

d. Set Voltmeter Calibrator for 100 mV output; connect 419A to Point A; adjust A4R42 (10 μV) for full scale deflection on 10 μV range.

NOTE

Remove resistive attenuator before performing steps e and f.

e. Set Voltmeter Calibrator for 1 mV output; connect 419A to Point B; adjust A4R43 (1 MV) for full scale deflection on 1 mV range.

f. Set Voltmeter Calibrator for 1 V output; connect 419A to Point B; adjust A4R44 (1 V) for full scale deflection on 1 V range.

5-39. BATTERY TEST CALIBRATION.

5-40. A DC Voltmeter (-hp- Model 427A) is required for the battery test calibration.

NOTE

Batteries must be fully charged before performing this procedure. (See Paragraph 3-13).

a. Remove 419A top cover and shield.

b. Connect DC Voltmeter across BT1 thru BT4. If DC Voltmeter indicates less than 26 V, recharge battery power supply in accordance with Paragraph 3-13. If DC Voltmeter indicates at least 26 V, proceed to step c.

c. Depress Model 419A BAT TEST Pushbutton; adjust A4R25 (BAT TEST CAL) for Model 419A Meter reading (0-3 scale) equal to DC Voltmeter reading in step b.

5-41. TROUBLESHOOTING.

5-42. This section contains information designed to assist in the isolation of malfunctions. These checks should be undertaken only after it has been established that the trouble cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-29.

NOTE

The 419A operates erratically when the charge on the batteries is marginal. Since the exact capacity of the Nickel Cadmium batteries cannot be determined by voltage measurements, it is advisable to charge the batteries before troubleshooting.

5-43. NO RESPONSE TO INPUT.

5-44. If the meter does not respond to input (usually accompanied by a constant offset near full scale after meter has been on for one or two minutes), proceed as follows:

a. If one neon is bad, all the pulses at A2TP2 will be the same amplitude. If the blocking oscillator is bad, there will be no pulses at A2TP2.

b. Check for approximately 8 volts dc at the emitter of Q4 to isolate between the blocking oscillator and its voltage regulator.

c. If the neon waveform at A2TP2 is correct, the trouble is in the amplifier.

5-45. POSITIVE OR NEGATIVE FOLDOVER.

5-46. Foldover is when the meter needle pegs and then returns on scale when the input is overloaded.

a. If positive foldover occurs, check A4Q12 for low gain.

b. If negative foldover occurs, check for low gain in A4Q13 and for a leaky A4C8 or C12.

5-47. EXCESSIVE NOISE.

5-48. If the 419A meter noise is in excess of 0.3 μV peak-to-peak, proceed as follows:

a. Check the batteries for low charge.

b. Check the chopper frequency in accordance with Paragraph 5-33. Misadjustment of chopper frequency or drive or a misfiring neon bulb will cause noise.

c. Clean the pin connectors on the A4 board with a fiberglass brush or typewriter eraser and ensure they are making good connections.

d. Check the transistors in the AC Amplifier for noise (A4Q1 or Q2 most probable).

5-49. TROUBLESHOOTING THE INPUT ATTENUATOR.

5-50. If trouble is suspected in the input attenuator or feedback divider, proceed as follows:

a. Rotate the range switch through all positions several times to clean the switch contacts.

b. Check the 90 MΩ resistor (S1R3) for dust accumulation; clean if necessary.

c. If trouble persists, carefully check the input attenuator and feedback divider resistors.

NOTE

Parallel paths exist for several of the resistors. Before replacing a suspected resistor, unsolder one lead and check the resistor again.

5-51. REPLACEMENT OF FACTORY SELECTED COMPONENTS.

5-52. Certain components within the Model 419A are individually selected in order to compensate for slightly varying circuit parameters. These components are identified by an asterisk (*) on the schematic diagrams and a typical value is shown. The following paragraphs describe the function of the factory selected components and give replacement instructions.

5-53. A4R26*.

5-54. A4R26* is factory selected to provide proper amplifier response time. Response time can be evaluated by performing the Response Time Test (Paragraph 5-13). A4R26* should be replaced only if response time cannot be corrected by performing the chopper adjustment procedure (Paragraphs 5-33). Paragraph 5-34 step e gives specific replacement instructions.

5-55. A4R47*.

5-56. A4R47* is factory selected to provide approximately 1.1 Vdc at the rear panel OUTPUT terminals into a 1 kΩ load with the LEVEL control turned fully cw and a full scale input applied to the INPUT terminals. Once A4R47* has been selected at the factory, there should be no reason to change its value unless one of the output transistors A4Q12 and A4Q13 or one of the diodes A4CR13 and A4CR14 is replaced. Factory values of A4R47* range from 16 kΩ to 20 kΩ with a typical value of 18 kΩ. A4R47* is an Allen-Bradley composition ±5% 1/2 watt resistor. If the value of A4R47* must be changed, proceed as follows:

a. Apply a 1 Vdc input to the Model 419A, INPUT terminals (1 V range).

b. Connect a 1 kΩ load across the rear panel OUTPUT terminals.

c. Turn LEVEL control fully cw.

d. Measure the voltage across the load. If the voltage is less than 1.0 Vdc, increase the value of A4R47*; if the voltage is greater than 1.15 Vdc, reduce the value of A4R47*.

e. After replacing A4R47*, perform the Full Scale Calibration procedure (Paragraph 5-37).

SECTION VI
CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

6-2. This section contains the circuit diagrams necessary for the operation and maintenance of the Model 419A DC Null Voltmeter. Included are schematic and component location diagrams.

6-3. SCHEMATIC DIAGRAMS.

6-4. The electrical configuration of the 419A is shown on the schematic diagrams. Individual schematics are provided for the metering circuit and the power supply circuit.

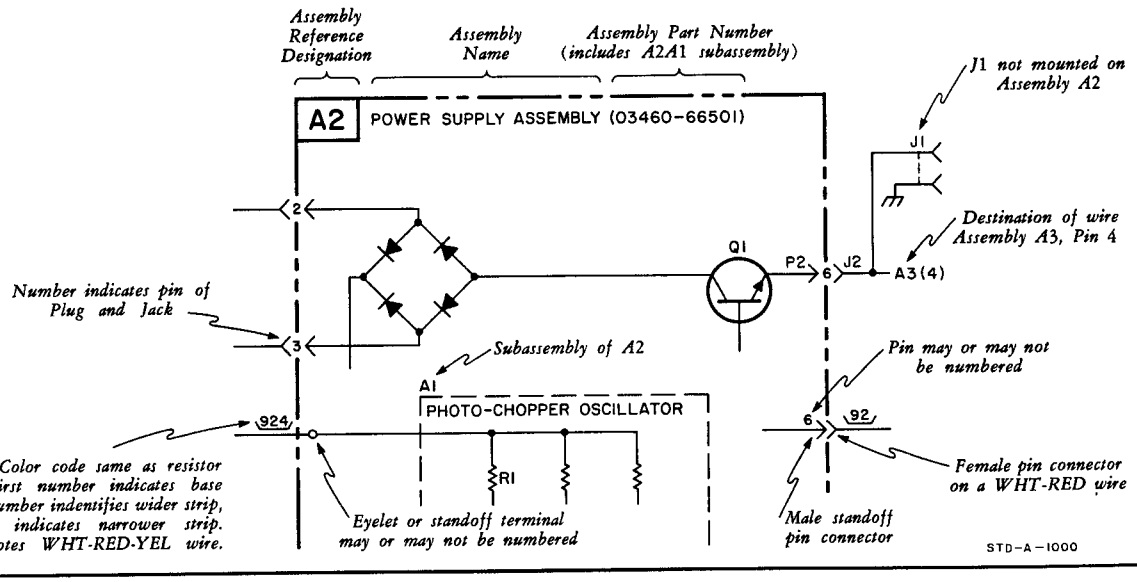
6-5. COMPONENT LOCATION DIAGRAMS.

6-6. The physical configuration of the 419A is shown on the component location diagrams. Each component is identified by reference designation.

REFERENCE DESIGNATIONS

PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.

ASSEMBLY	SUBASSEMBLY	COMPONENT	COMPLETE DESIGNATION
A2	NONE	Q1	A2Q1
A2	A1	R1	A2A1R1
NONE	NONE	J1	J1


Assembly Reference Designation
Assembly Name
Assembly Part Number (includes A2A1 subassembly)
A2
POWER SUPPLY ASSEMBLY (03460-66501)
J1 not mounted on Assembly A2
J1
Destination of wire Assembly A3, Pin 4
A3(4)
Q1
P2
J2
Number indicates pin of Plug and Jack
Subassembly of A2
A1
PHOTO-CHOPPER OSCILLATOR
Pin may or may not be numbered
924
92
R1
Wire Color: Color code same as resistor color code. First number indicates base color, second number indentifies wider strip, third number indicates narrower strip. E.g. 924 denotes WHT-RED-YEL wire.
Eyelet or standoff terminal may or may not be numbered
Female pin connector on a WHT-RED wire
Male standoff pin connector
STD-A-1000

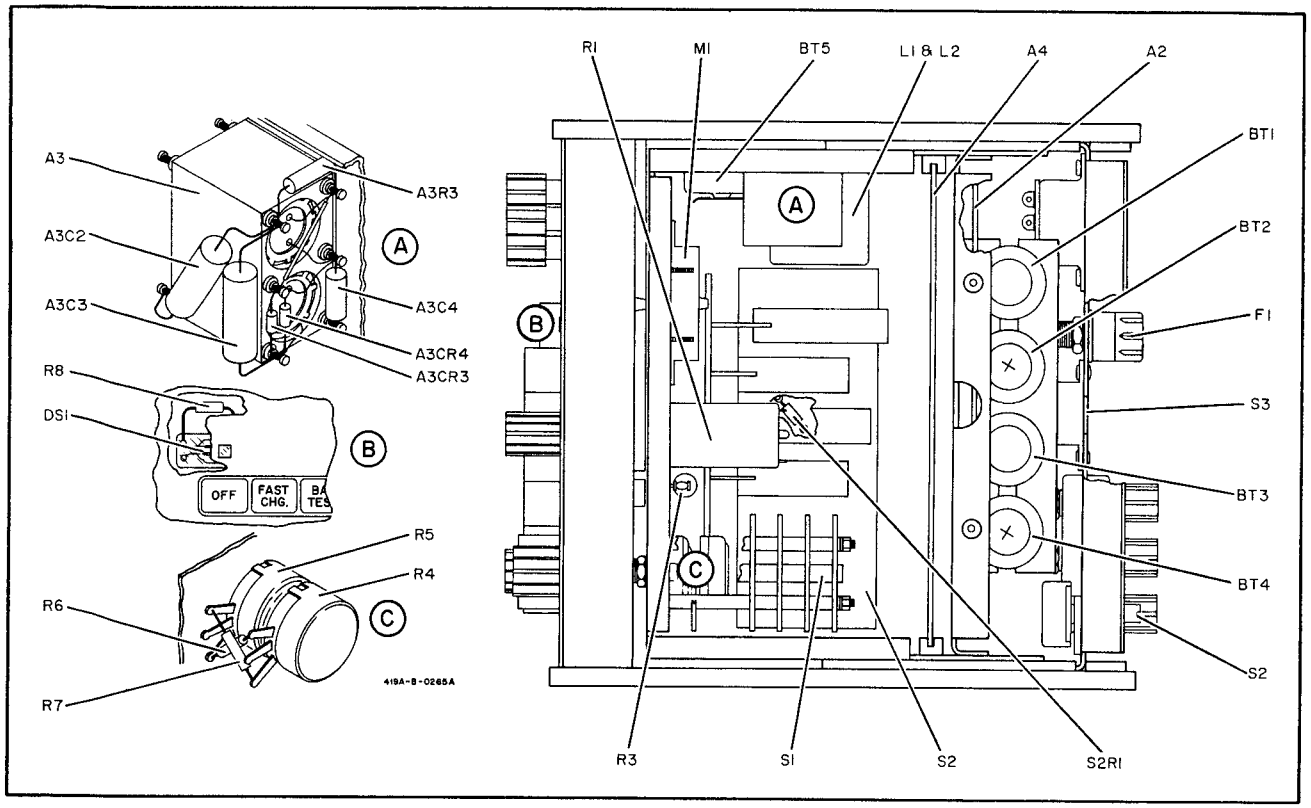


Figure 6-1. Model 419A, Component Location Diagram

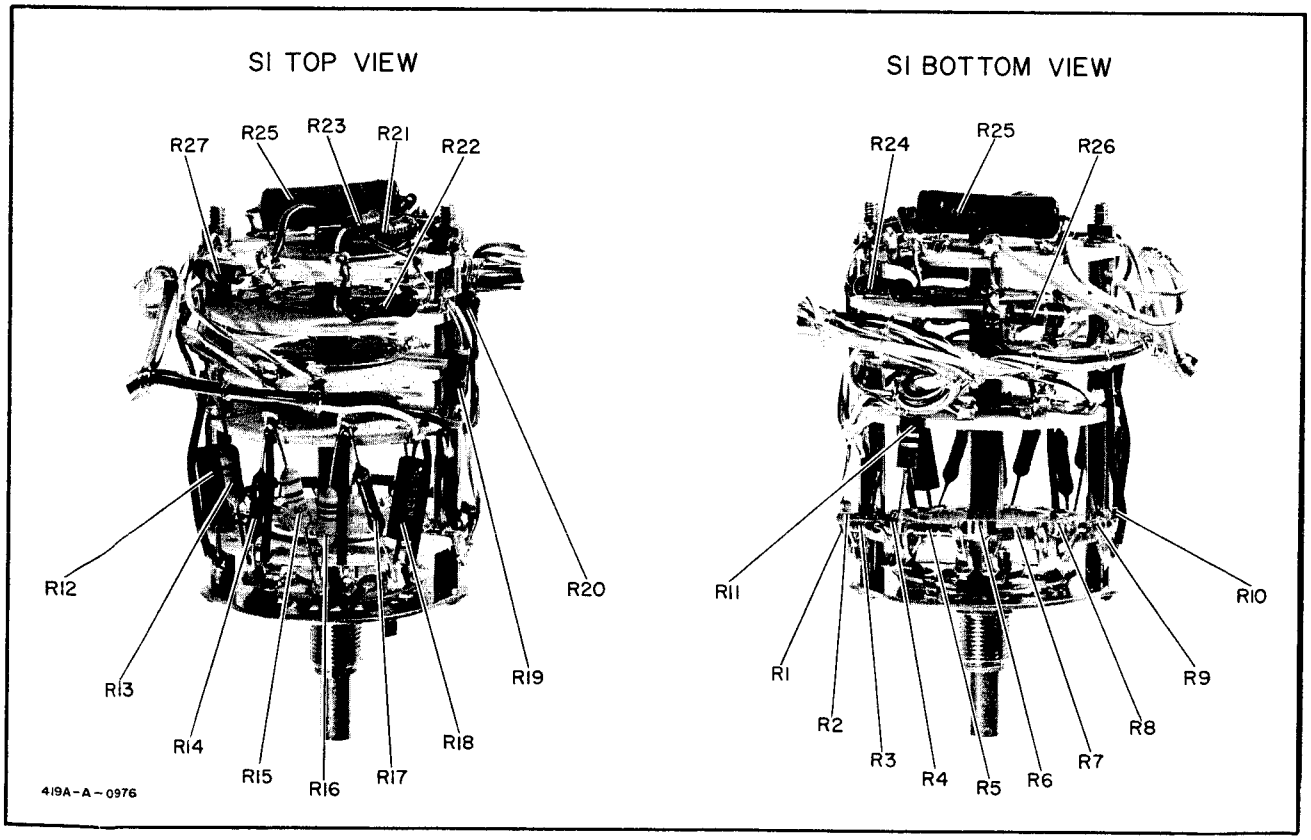


Figure 6-2. Range Switch S1, Component Location Diagram

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION.

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

7-6. NON-LISTED PARTS.

7-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
B	= battery	HR	= heater	Q	= transistor	W	= cable
C	= capacitor	J	= jack	QCR	= transistor-diode	X	= socket
CR	= diode	K	= relay	R	= resistor	XDS	= lampholder
DL	= delay line	L	= inductor	RT	= thermistor	XF	= fuseholder
DS	= lamp	M	= meter	S	= switch	Z	= network
E	= misc electronic part	MC	= microcircuit	T	= transformer		

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9} seconds	sl	= slide
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPDT	= single-pole double-throw
A	= ampere (s)	incd	= incandescent			SPST	= single-pole single-throw
Au	= gold	ins	= insulation (ed)				
C	= capacitor	kΩ	= kilohm (s) = 10^{+3} ohms	Ω	= ohm (s)	Ta	= tantalum
cer	= ceramic	kHz	= kilohertz = 10^{+3} hertz	obd	= order by description	TC	= temperature coefficient
coef	= coefficient			OD	= outside diameter	TiO_2	= titanium dioxide
com	= common	L	= inductor				
comp	= composition	lin	= linear taper	p	= peak	tog	= toggle
conn	= connection	log	= logarithmic taper	pc	= printed circuit	tol	= tolerance
dep	= deposited					trim	= trimmer
DPDT	= double-pole double-throw	m	= milli = 10^{-3}	pF	= picofarad (s) = 10^{-12} farads	TSTR	= transistor
DPST	= double-pole single-throw	mA	= milliampere (s) = 10^{-3} amperes	piv	= peak inverse voltage	V	= volt (s)
		MHz	= megahertz = 10^{+6} hertz	p/o	= part of	vacw	= alternating current working voltage
elect	= electrolytic	MΩ	= megohm-(s) = 10^{+6} ohms	pos	= position (s)	var	= variable
encap	= encapsulated	met flm	= metal film	poly	= polystyrene	vdcw	= direct current working voltage
		mfr	= manufacturer	pot	= potentiometer		
F	= farad (s)	mtg	= mounting	p-p	= peak-to-peak		
FET	= field effect transistor	mV	= millivolt (s) = 10^{-3} volts	ppm	= parts per million	W	= watt (s)
fxd	= fixed	μ	= micro = 10^{-6}	prec	= precision (temperature coefficient, long term stability, and/or tolerance)	w/	= with
		μV	= microvolt (s) = 10^{-6} volts			wiv	= working inverse voltage
GaAs	= gallium arsenide	my	= Mylar Ⓡ			w/o	= without
GHz	= gigahertz = 10^{+9} hertz					ww	= wirewound
gd	= guard (ed)	nA	= nanoampere (s) = 10^{-9} amperes	R	= resistor	*	= optimum value selected at factory, average value shown (part may be omitted)
Ge	= germanium	NC	= normally closed	Rh	= rhodium		
grd	= ground (ed)	Ne	= neon	rms	= root-mean-square		
		NO	= normally open	rot	= rotary		
H	= henry (ies)	NPO	= negative positive zero (zero temperature coefficient)	Se	= selenium	**	= no standard type number assigned (selected or special type)
Hg	= mercury			sect	= section (s)		
Hz	= hertz (cycle (s) per second)			Si	= silicon		

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Table 7-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A1				Not Assigned			
A2	00419-66502		1	Assembly: Power Supply			
A2C1	0180-0149		1	C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	Type 30D	obd
A2C2	0150-0093		1	C: fxd 0.01 μF +80% -20% 100 vdcw	91418	TA	obd
A2C3	0180-0059		1	C: fxd elect 10 μF +100% -10% 25 vdcw	56289	30D106G025 BB4	
A2C4	0160-0161		1	C: fxd 0.01 μF ±10%	56289	192P10392	
A2CR1 thru A2CR4	1901-0025		2	Diode: Si 100 mA at +1 V 100 piV 12 pF	93332	D3072	
A2CR5	1902-0048		1	Diode: breakdown 6.81 V ±5%	07910	CD35658	
A2CR6 thru A2CR8	1901-0025			Diode: Si 100 mA at +1 V 100 piV 12 pF	93332	D3072	
A2CR9	1902-0563		1	Diode: breakdown 100 μA 22.1 V ±2%	04713	SZ11327	
A2Q1 thru A2Q3	1854-0039		3	Transistor: NPN Si 2N3053	86684	2N3053	
A2Q4	1854-0033		9	Transistor: NPN Si 2N3391	24446	2N3391	
A2Q5	1853-0010		4	Transistor: PNP Si**	04713	SM4713	
A2R1	0687-1511		1	R: fxd comp 150 Ω ±10% 1/2 W	01121	EB1511	
A2R2	0686-7515		1	R: fxd comp 750 Ω ±5% 1/2 W	01121	EB7515	
A2R3	0687-5611		1	R: fxd comp 560 Ω ±10% 1/2 W	01121	EB5611	
A2R4	0687-3331		1	R: fxd comp 33 kΩ ±10% 1/2 W	01121	EB3331	
A2R5	2100-1410		5	R: var lin 20 kΩ ±30% 1/8 W	71450	XQS-200	obd
A2R6	0687-4731		1	R: fxd comp 47 kΩ ±10% 1/2 W	01121	EB4731	
A2R7, A2R8	0686-5105		1	R: fxd comp 51 Ω ±5% 1/2 W	01121	EB5105	
A2R9	2100-0362		1	R: var lin 100 kΩ ±30% 1/8 W	71450	XQS-200	obd
A2R10	0687-4721		2	R: fxd comp 4700 Ω ±10% 1/2 W	01121	EB4721	
A2R11	0687-1051		1	R: fxd comp 1 MΩ ±10% 1/2 W	01121	EB1051	
A2R12	0687-4741		1	R: fxd comp 470 kΩ ±10% 1/2 W	01121	EB4741	
A2T1	9100-0172		1	Transformer: power	28480	9100-0172	
A2T2	9100-1319		1	Transformer: neon driver	28480	9100-1319	
A3	00419-63001		1	Assembly: Photochopper	28480	00419-63001	
A3A1	1990-0214		1	Subassembly: Neon Driver	28480	1990-0214	
A3C1				Not Assigned			
A3C2	0160-0859		2	C: fxd my die 1.0 μF ±10% 50 vdcw	56289	148P	obd
A3C3	0170-0064		1	C: fxd my die 0.47 μF ±10% 100 vdcw	56289	148P4791	
A3C4	0160-2446		1	C: fxd poly die 0.1 μF ±20% 200 vdcw	84411	863 UW	
A3CR1, A3CR2				Not Assigned			
A3CR3, A3CR4	1901-0156		2	Diode: Si 50 mA at 1 Vdc 20 piV	01281	PS5553	
A3R1, A3R2				Not Assigned			
A3R3	0811-1505		2	R: fxd prec ww 100 Ω ±0.1% 1/2 W	01686	E-20	obd
A3V1 thru A3V4	00419-63001			Photocells: part of A3 (not separately replaceable)	28480	00419-63001	
A4	00419-66504		1	Assembly: amplifier	28480	00419-66504	
A4C1	0180-0224		3	C: fxd Al elect 10 μF +75% -10% 15 vdcw	56289	30D106G015 BA4	
A4C2	0180-0060		1	C: fxd elect 200 μF +100% -10% 3 vdcw	56289	30D207G003 DC4	
A4C3	0150-0069		2	C: fxd cer die 0.001 μF +100% -20% 500 vdcw	72982	#801-010X5G 0102Z	
A4C4	0180-0100		1	C: fxd Ta die 4.7 μF ±10% 35 vdcw	56289	150D475X903 5B2	
A4C5	0150-0069			C: fxd cer die 0.001 μF +100% -20% 500 vdcw	72982	#801-010X5G 0102Z	

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A4C6, A4C7	0180-0224			C: fxd Al elect 10 μF +75% -10% 15 vdcw	56289	30D106G015 BA4	
A4C8	0180-0061		2	C: fxd elect 100 μF +100% -10% 15 vdcw	56289	30D107G015 DD4	
A4C9	0160-0859			C: fxd my die 1.0 μF ±10% 50 vdcw	56289	148P	obd
A4C10	0180-0100		1	C: fxd Ta die 4.7 μF ±10% 35 vdcw	56289	150D475X9035 B2	
A4C11	0180-0155		1	C: fxd Ta elect 2.2 μF ±20% 20 vdcw	56289	150D225X0020 AZ	
A4C12	0180-0061			C: fxd elect 100 μF +100% -10% 15 vdcw	56289	30D107G015 DD4	
A4C13	0160-0932		1	C: fxd my die 4 μF ±20% 30 vdcw	56289	Type 148P	
A4C14, A4C15	0180-0228		2	C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015 B2-DYS	
A4C16	0180-0393		1	C: fxd Ta elect 39 μF ±10% 10 vdcw	56289	150D396X9010 B2-DYS	
A4C17	0180-0228			C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015 B2-DYS	
A4CR1 thru A4CR16	1901-0025			Diode: Si 100 mA at +1 V 100 piV 12 pF	93332	D3072	
A4Q1, A4Q2	1854-0226		2	Transistor: NPN Si	56289	TN-56	
A4Q3	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q4	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4Q5	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q6	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4Q7 thru A4Q10	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q11	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4Q12	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q13	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4R1	0757-0374		2	R: fxd prec met flm 475 kΩ ±1% 1/2 W	19701	MF7C T-O	obd
A4R2	0757-0129		1	R: fxd prec met flm 178 kΩ ±1% 1/2 W	19701	MF7C T-O	obd
A4R3	0687-1241		3	R: fxd comp 120 kΩ ±10% 1/2 W	01121	EB1241	
A4R4	0687-1041		5	R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
A4R5	0687-5601		1	R: fxd comp 56 Ω ±10% 1/2 W	01121	EB5601	
A4R6	0687-5621		1	R: fxd comp 5600 Ω ±10% 1/2 W	01121	EB5621	
A4R7	0687-1211		1	R: fxd comp 120 Ω ±10% 1/2 W	01121	EB1211	
A4R8	0757-0374			R: fxd prec met flm 475 kΩ ±1% 1/2 W	19701	MF7C T-O	obd
A4R9	0687-4751		1	R: fxd comp 4.7 MΩ ±10% 1/2 W	01121	EB4751	
A4R10	0687-4721			R: fxd comp 4700 Ω ±10% 1/2 W	01121	EB4721	
A4R11	0687-2251		1	R: fxd comp 2.2 MΩ ±10% 1/2 W	01121	EB2251	
A4R12, A4R13	0687-5631		2	R: fxd comp 56 kΩ ±10% 1/2 W	01121	EB5631	
A4R14	2100-1410			R: var lin 20 kΩ ±30% 1/8 W	71450	XQS-200	obd
A4R15	0687-1031		4	R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031	
A4R16	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
A4R17	0687-1241			R: fxd comp 120 kΩ ±10% 1/2 W	01121	EB1241	
A4R18	0687-1031			R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031	
A4R19	0687-1021		4	R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021	
A4R20	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
A4R21	0687-2231		3	R: fxd comp 22 kΩ ±10% 1/2 W	01121	EB2231	
A4R22	0687-1241			R: fxd comp 120 kΩ ±10% 1/2 W	01121	EB1241	
A4R23 thru A4R25	0687-1021			R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021	
A4R26*				See Paragraph 5-53			
A4R27	0687-1051			R: fxd comp 1 MΩ ±10% 1/2 W	01121	EB1051	
A4R28	0687-2231			R: fxd comp 22 kΩ ±10% 1/2 W	01121	EB2231	

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A4R29	0687-2221		7	R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221	
A4R30	0687-4741			R: fxd comp 470 kΩ ±10% 1/2 W	01121	EB4741	
A4R31 thru A4R33	0687-2241		3	R: fxd comp 220 kΩ ±10% 1/2 W	01121	EB2241	
A4R34 thru A4R36	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221	
A4R37	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
A4R38	0687-3951		2	R: fxd comp 3.9 MΩ ±10% 1/2 W	01121	EB3951	
A4R39	0687-1031			R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031	
A4R40	0687-1011			R: fxd comp 100 Ω ±10% 1/2 W	01121	EB1011	
A4R41 thru A4R44	2100-1795			R: var comp lin 250 kΩ ±20% 1/8 W	71450	QS 200	
A4R45	2100-1470		1	R: var lin 500 kΩ ±30% 1/10 W	71450	XQS-200	obd
A4R46	0687-3941		1	R: fxd comp 390 kΩ ±10% 1/2 W	01121	EB3941	
A4R47*				See Paragraph 5-55			
A4R48	0687-6831		1	R: fxd comp 68 kΩ ±10% 1/2 W	01121	EB6831	
A4R49	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221	
A4R50	0687-1031			R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031	
A4R51	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221	
BT1 thru BT4	1420-0015		4	Battery: rechargeable nickel cadmium 6.25 V	61637	Y-5201	
BT5	1420-0004		1	Battery: mercury 1.34 V cylindrical	09569	316469	
DS1	2140-0008		1	Lamp: glow type NE-2 neon	28480	2140-0008	
F1	2110-0027		1	Fuse: cartridge 1/8 amp 250 V	75915	312.125	
J1	1251-0148		1	Connector: ac power cord receptacle	0000U	H-1061-2	
J2	5080-1278		1	Binding Post: red with solder turret (+ INPUT)	28480	5080-1278	
	0340-0159		2	Insulator Cup: binding post	28480	0340-0159	
	0340-0100		2	Insulator Spacer: binding post	28480	0340-0100	
	00419-21701		2	Guard: binding post, threaded	28480	00419-21701	
J3	5080-1277			Binding Post: black with solder turret (- INPUT)	28480	5080-1277	
	0340-0159			Insulator Cup: binding post	28480	0340-0159	
	0340-0100			Insulator Spacer: binding post	28480	0340-0100	
	00419-21701			Guard: binding post, threaded	28480	00419-21701	
J4	1510-0011		3	Binding Post: black with solder turret (⏚)	28480	1510-0011	
	0340-0099		1	Insulator: binding post	28480	0340-0099	
J5	1510-0010		1	Binding Post: red with solder turret (+ OUTPUT)	28480	1510-0010	
J6	1510-0011			Binding Post: black with solder turret (- OUTPUT)	28480	1510-0011	
J7	1510-0011			Binding Post: black with solder turret (⏚)	28480	1510-0011	
	0340-0086		1	Insulator: binding post, dual	28480	0340-0086	
	0340-0091		1	Insulator: binding post, triple	28480	0340-0091	
L1, L2	9100-1318		1	Inductor: input	28480	9100-1318	
M1	1120-0312		1	Meter	28480	1120-0312	
R1	2100-1557		1	R: var prec ww 10 turn 100 kΩ ± 5% 2 W	12697	Series 62 CM 33147	
R2	2100-2200		1	R: var lin 20 kΩ ±20% 1/3 W	71450	Series 45	
R3	0698-3463		1	R: fxd prec c flm 90 MΩ ±1% 2 W	03888	HV2000	obd
R4, R5	2100-2199		2	R: var comp 2 sect lin tandem ganged 1500 Ω and 5000 Ω ±20%	12697	Series 53M	
R6, R7	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221	
R8	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
R9	0687-2721		1	R: fxd comp 2700 Ω ±10% 1/2 W	01121	EB2721	

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Sacramento, 95821
2591 Carlsbad Ave.
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TWX: 916-444-8683

San Diego, 92106
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TWX: 714-276-4263

Palo Alto, 94303
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7965 East Prentice
(303) 771-3455
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TWX: 710-428-2036

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(213) 877-1282
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(312) 677-0400
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TWX: 710-862-0850

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TWX: 710-332-0382

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TWX: 313-357-4425

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TWX: 910-563-3734

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Kansas City, 64114
9208 Wyoming Place
(816) 333-2445
TWX: 910-771-2087

St. Louis, 63144
2812 South Brentwood Blvd.
(314) 644-0220
TWX: 910-760-1670

NEW JERSEY
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Englewood, 07631
391 Grand Avenue
(201) 567-3933
TWX: 510-230-9709

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TWX: 910-989-1655

Las Cruces, 88001
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(505) 526-2486
TWX: 910-983-0550

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236 East 75th Street
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TWX: 710-581-4376

Rochester, 14623
39 Saginaw Drive
(716) 473-9500
TWX: 510-253-5981

Poughkeepsie, 12601
82 Washington Street
(914) 454-7330
TWX: 914-452-7425

Syracuse, 13211
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(315) 454-2486
TWX: 710-541-0482

Endicott, 13764
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(919) 882-6873
TWX: 510-926-1516

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TWX: 216-888-0715

Dayton, 45409
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(513) 298-0351
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MANUAL BACKDATING CHANGES

MODEL 419A

DC NULL VOLTMETER

Manual Serial Prefixed: 707-
-hp- Part No. 00419-90002

This manual backdating sheet makes this manual applicable to earlier instruments. Instrument-component values that differ from those in the manual, yet are not listed in the backdating sheet, should be replaced using the part number given in the manual.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
646-	1		
532-0401 and above	1, 2		
532-0400 and below	1, 2, 3		
514-	1, 2, 3, 4		

CHANGE 1

Figures 6-1 and 6-3:
Substitute Figures C-1 and C-2 for the ones in Figures 6-1 and 6-3.

Table 7-1:
Change all "A4" reference designators to "A1."
Change -hp- Part No. of A1 to 00419-66504.
Change A1C13 to -hp- Part No. 0180-0022, C: fxd, elect 3.9 μF 35 vdcw.
Delete A1C14 thru A1C17.
Change "A1CR1 thru A1CR16" to "A1CR1 thru A1CR14."
Change A1R38 to -hp- Part No. 0686-3055, R: fxd comp 3 MΩ $\pm$5% 1/2 W.
Change A1R41 thru A1R44 to -hp- Part No. 2100-1410, R: var lin 20 kΩ $\pm$30% 1/8 W.
Change A1R48 to -hp- Part No. 0687-6821, R: fxd comp 6.8 kΩ $\pm$10% 1/2 W.
Delete A1R50 and A1R51.
Add C1, -hp- Part No. 0180-0283, C: fxd Al elect 60 μF +75% -10% 10 vdcw.

CHANGE 2

Table 7-1:
Change J2 to -hp- Part No. 1510-0010.
Change J3 to -hp- Part No. 1510-0011.
Change J5 to -hp- Part No. 1510-0026.
Change J6 to -hp- Part No. 1510-0027.

CHANGE 3

Figure 6-3:
Change A1R26* (10 K) to A1R26* (22 K).
Move A1R26 between A1CR3 and 4 and Q8 Base.
Delete C10 (3.7 μF) in emitter of Q12 and Q13.
Add C10 (20 μF) between A1-13 and $\triangledown$.
Short R40 (100 Ω) in base of A1Q10.
Add R40 (39 kΩ) between A1C13 and A1R39.

Table 7-1:
Change A1C10 to C: fxd Al elect 20 μF +75% -10% 25 vdcw; -hp- Part No. 0180-0045.
Change A1R26* to R: fxd 22 K $\pm$10% 1/2 W; -hp- Part No. 0687-1031.
Change A1R40 to R: fxd 39 K $\pm$10% 1/2 W; -hp- Part No. 0687-3931.

MANUAL BACKDATING CHANGES

CHANGE 4

Change Paragraph 5-34 steps d and e as follows:

d. A2R12, CHOPPER CURRENT, affects both the chopper frequency and current. Adjust A2R12 for waveshape shown in Figure 5-3 with peak amplitude of 140 to 160 mV and frequency of 320 to 340 pps (this corresponds to chopper rate of 160 to 170 pps as counter also counts smaller pulses).

e. . . . A1R26 should be between 10 KΩ and 39 KΩ with a typical value of 22 KΩ.

Figure 6-4:
Substitute Figure C-3 and C-4 for the ones in Figure 6-4.

Table 7-1:
Change A2Q1 to -hp- Part No. 1854-0039, Transistor: NPN, Si, 2N3053
Change A2Q2, A2Q3 to -hp- Part No. 1854-0033, Transistor: NPN, Si, 2N2925
Change A2Q4, A2Q5 to -hp- Part No. 1854-0039, Transistor: NPN, Si, 2N3053
Change A2R1 to -hp- Part No. 0687-5611, R: fxd, comp, 560 ohms ±10%, 1/2 w
Change A2R2 to -hp- Part No. 0687-6811, R: fxd, comp, 680 ohms ±10%, 1/2 w
Change A2R3 to -hp- Part No. 0687-3331, R: fxd, comp, 33 K ohms ±10%, 1/2 w
Change A2R4 to -hp- Part No. 0687-3321, R: fxd, comp, 3300 ohms ±10%, 1/2 w
Change A2R5 to -hp- Part No. 0687-6801, R: fxd, comp, 68 ohms ±10%, 1/2 w
Change A2R6 to -hp- Part No. 0687-2731, R: fxd, comp, 27 K ohms ±10%, 1/2 w
Change A2R7 to -hp- Part No. 0687-4731, R: fxd, comp, 47 K ohms ±10%, 1/2 w
Change A2R8, A2R9 to -hp- Part No. 0687-4701, R: fxd, comp, 47 ohms ±10%, 1/2 w
Change A2R10 to -hp- Part No. 0687-1511, R: fxd, comp, 150 ohms ±10%, 1/2 w
Change A2R11 to -hp- Part No. 0687-3341, R: fxd, comp, 330 K ohms ±10%, 1/2 w
Change A2R12 to -hp- Part No. 2100-0227, R: var, ww, 20 ohms ±10%, 1-1/2 w
Change A2T1 to -hp- Part No. 9100-0172, Transformer: power
Change A2T2 to -hp- Part No. 9100-1314, Transformer: neon driver

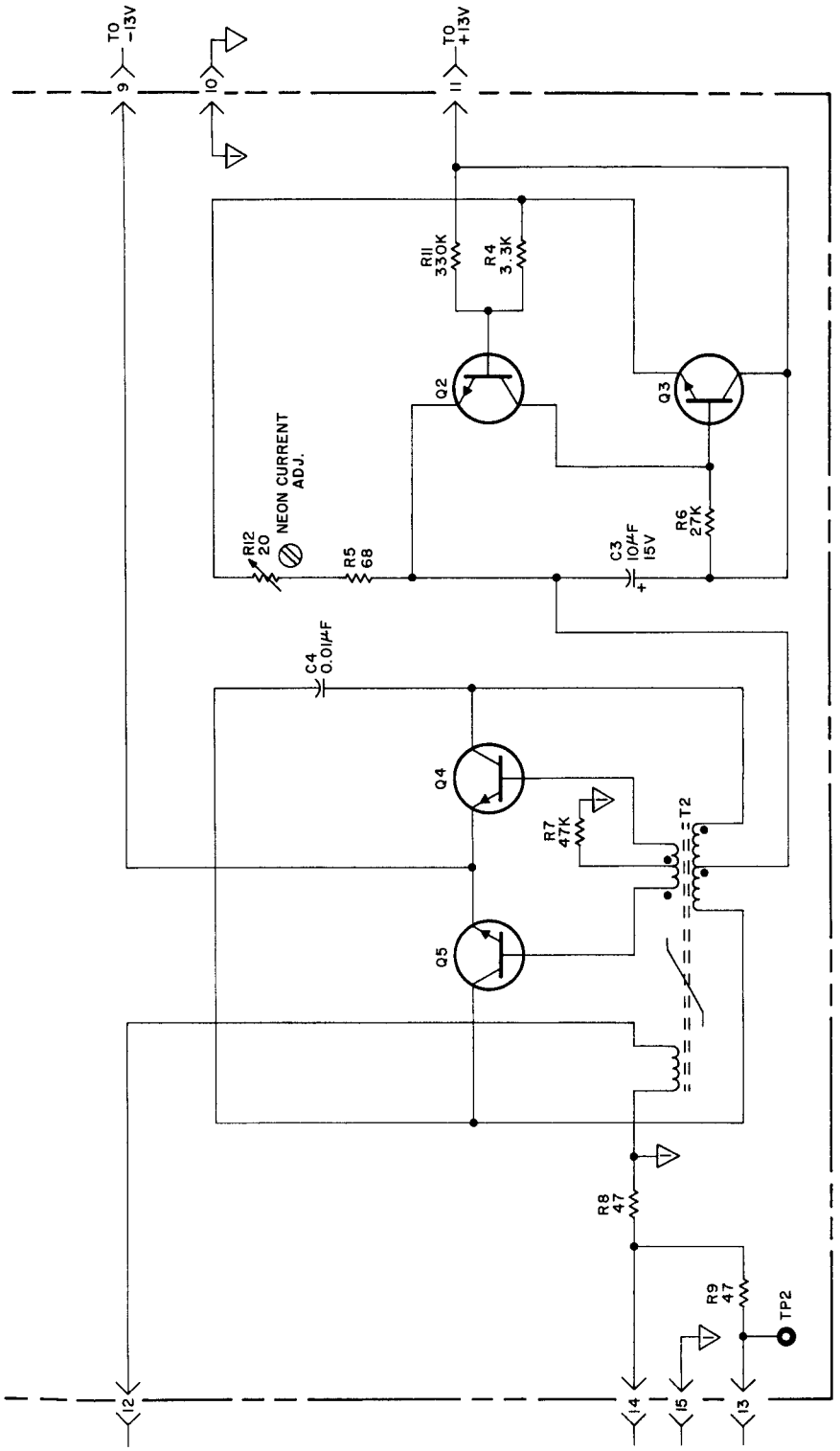

Figure C-3. Neon Driver (Serials Prefixed 514-)

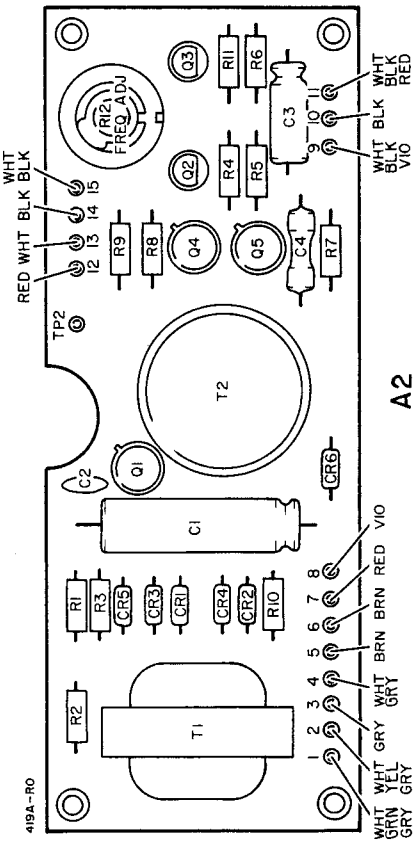

Figure C-4. A2 Board (Serials Prefixed 514-)

Figure 1-1. Model 419A DC Null Voltmeter

Table 1-1. Model 419A Specifications

VOLTMETER

Ranges: ±3 μV to ±1000 volts dc end scale in 18 zero center ranges.

Accuracy: ±(2% of end scale +0.1 μV).

Limits of Zero Control: ±15 μV.

Input Resistance:

3 μV to 3 mV ranges: 100 kΩ (infinite when nulled).

10 mV to 30 mV ranges: 1 MΩ (infinite when nulled).

100 mV to 300 mV ranges: 10 MΩ (infinite when nulled).

1 volt to 1000 volt ranges: 100 MΩ

Internal Bucking Voltage: ±120% end scale, 3 μV through 300 mV range.

Response Time: 95% of final reading within 3 sec on the 3 μV range. 95% of final reading within 1 sec on the 10 μV to 1000 V ranges.

Superimposed AC Rejection: Ac voltages 60 Hz and above: 80 db greater than end scale--affects reading less than 2%. Peak ac voltage not to exceed max overload voltage.

Drift: < 0.5 μV/day after 30 minutes warmup. T.C. < 0.05 μV/°C from 0° to +50°C.

Noise*: < 0.3 μV peak-to-peak.

* Peak-to-peak noise is less than 0.3 μV 95% of the time since the noise amplitude approximates a Gaussian distribution where the standard deviation (which is also the rms value) = 0.075 μV.

AMPLIFIER

Gain: 110 db maximum at recorder output terminals. Gain depends on range.

Output: 0 to ±1 volt at 1 mA max for end scale reading. Output level is adjustable for convenience when used with recorders.

Output Impedance: Depends on setting of output level control. < 35 ohms when output level is set to maximum.

Noise: 0.01 Hz to 5 Hz: Same as voltmeter (referred to input). > 5 Hz: rms noise < 10 mV (referred to output).

DC AMMETER

Current Ranges: ±30 pA, ±100 pA, ±300 pA, ±1 nA, ±3 nA, ±10 nA and ±30 nA.

Accuracy: ±(3% of end scale +1 pA).

GENERAL

Overload Voltages: 50 Vdc max, 3 μV to 3 mV ranges; 500 Vdc max, 10 mV to 300 mV ranges; 1200 Vdc max on 1 volt range and above.

Overload Recovery Time: Meter indicates within 3 seconds for a 10^6 overload.

Input Terminals: Positive and negative terminals are solid copper, gold flashed.

Input Isolation: > 10^{10} ohms shunted by 250 pF. May be operated up to 500 Vdc or 350 Vac (rms) above ground.

Operating Temperature: 0° to +50°C.

Storage Temperature: -40°C to +60°C.

Power Source: 4 internal rechargeable batteries (furnished). Thirty hour operation per recharge. The 419A may be operated during recharge from ac line. 115 or 230 V ±10%, 50 to 1000 Hz, approximately 3 watts.

Dimensions: Standard -hp- 1/2 module; 6" high, 7-3/4" wide, 8" deep (152 x 197 x 203 mm).

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OPERATING AND SERVICE MANUAL

(HP PART NO. 00419-90002)

MODEL 419A
DC NULL VOLTMETER

SERIALS PREFIXED: 707-

Appendix C, Manual Backdating Changes, adapts this manual to Serials Prefixed: 514-, 532-, 646-

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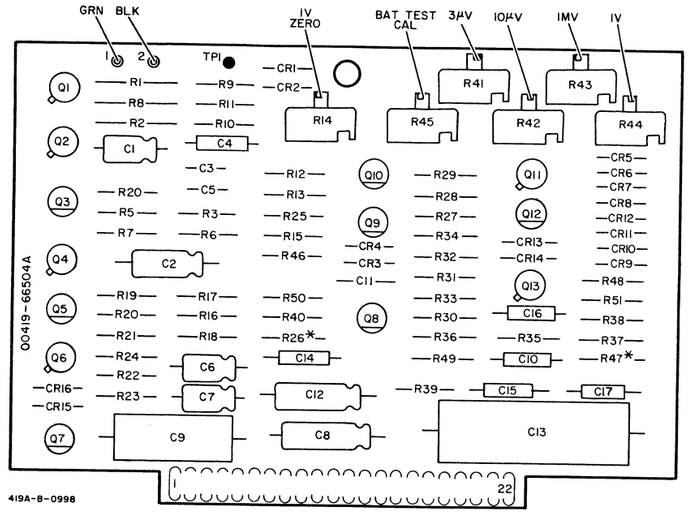

A4
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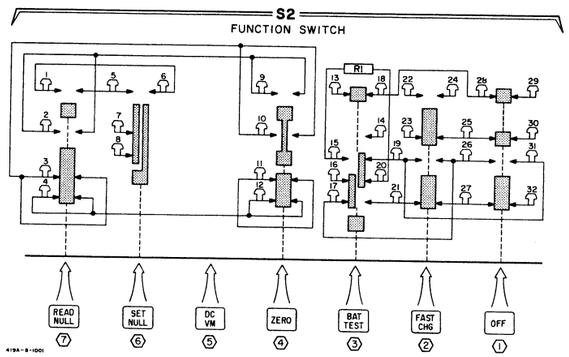
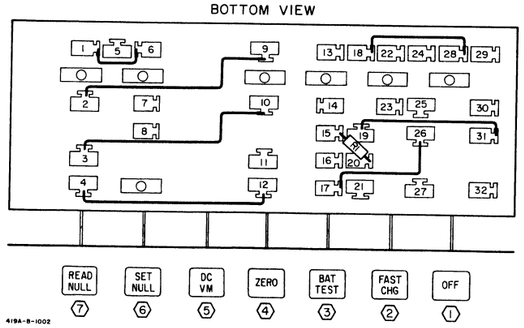


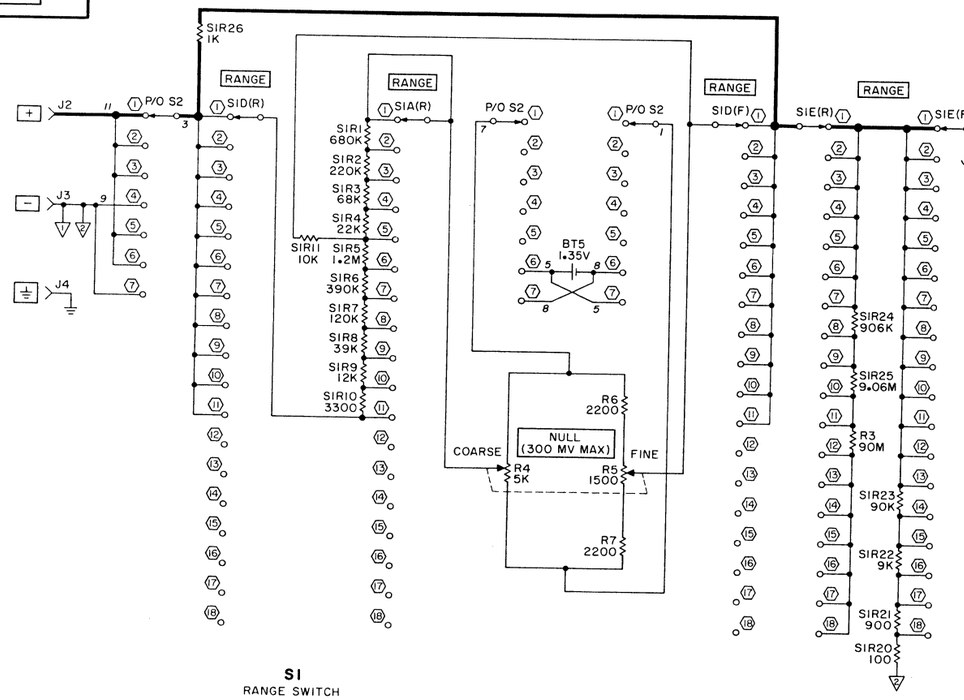


NOTES

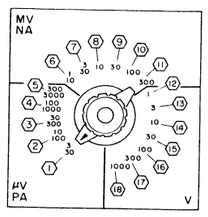
1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. ⏚ DENOTES POWER LINE (CHASSIS) GROUND.
   ▽ DENOTES POWER SUPPLY COMMON.
   ▽ DENOTES SIGNAL COMMON.
4. DENOTES ASSEMBLY.
   DENOTES MAIN SIGNAL PATH.
   DENOTES DC FEEDBACK PATH.
   DENOTES AC FEEDBACK PATH.
5. DENOTES FRONT PANEL MARKING.
   DENOTES REAR PANEL MARKING.
6. DENOTES SCREWDRIVER ADJUST.
7. (924) DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR. SECOND NUMBER IDENTIFIES WIDER STRIP. THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g. (924) -WHITE, RED, YELLOW.)

WIRE COLOR	
0	BLK
1	BRN
2	RED
3	ORN
4	YEL
5	GRN
6	BLU
7	VIO
8	GY
9	WHT

8. * AVERAGE VALUE SHOWN. OPTIMUM VALUE SELECTED AT FACTORY. SEE PARAGRAPH 5-51 FOR REPLACEMENT INSTRUCTIONS.
9. DENOTES TWISTED PAIR.
10. VOLTAGES INDICATED IN RED ARE MEASURED WITH VM PUSHBUTTON DEPRESSED, 1 V RANGE. INPUT SHORTED. ALL VOLTAGES ARE ±10%.



S1
RANGE SWITCH



S2
FUNCTION SWITCH

OFF	FAST CHG.	BAT. TEST	ZERO	VM AM	SET NULL	READ NULL
1	2	3	4	5	6	7

419A-J-0963

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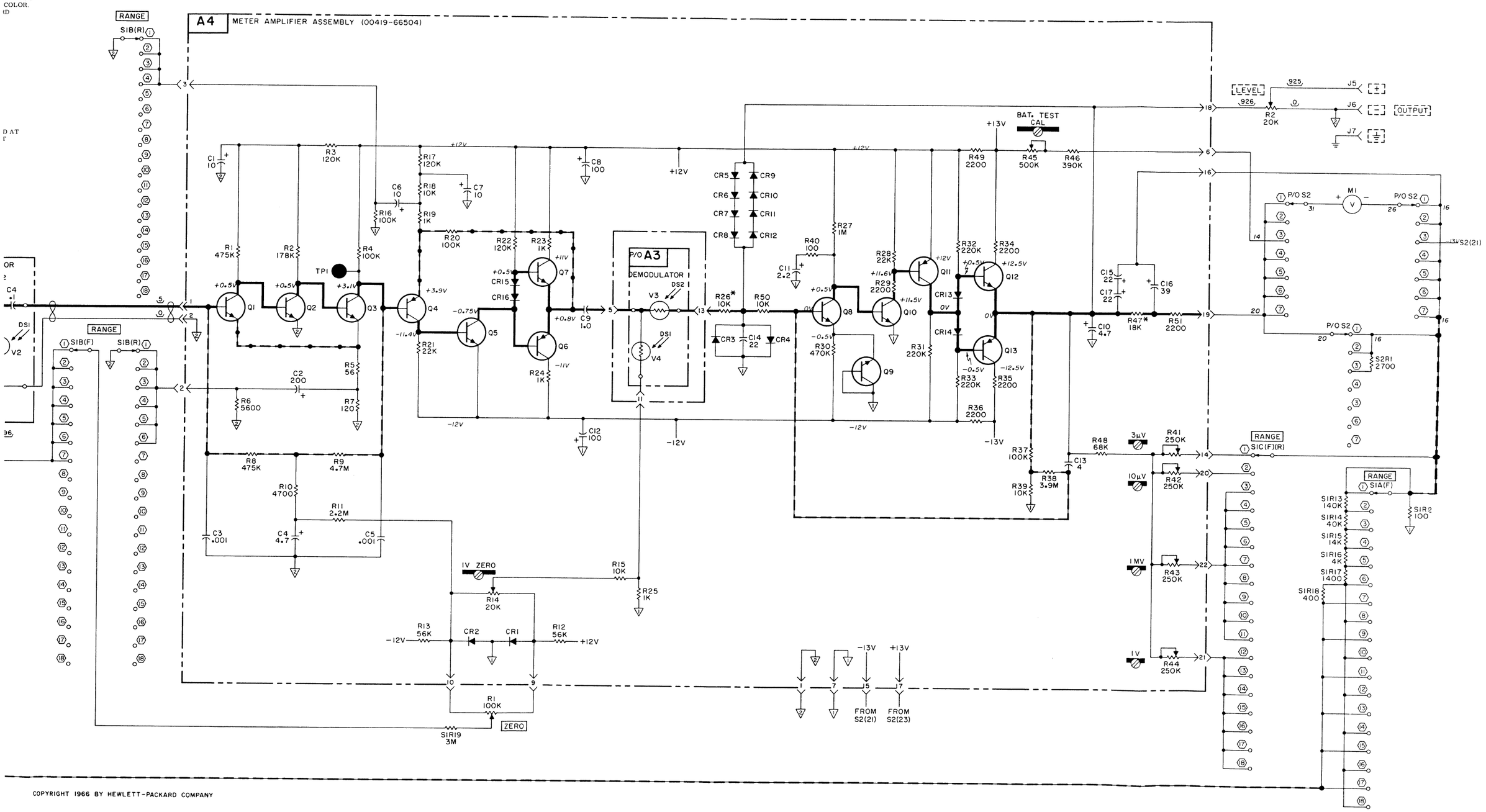

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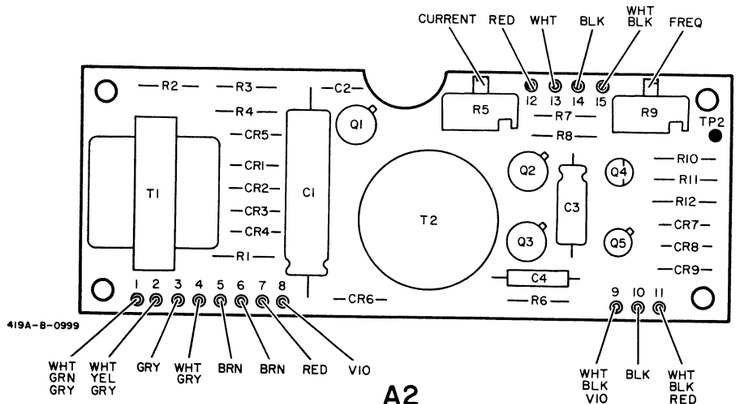
Figure 6-3. Amplifier and Amplifier Switching Schematic and Component Location Diagrams



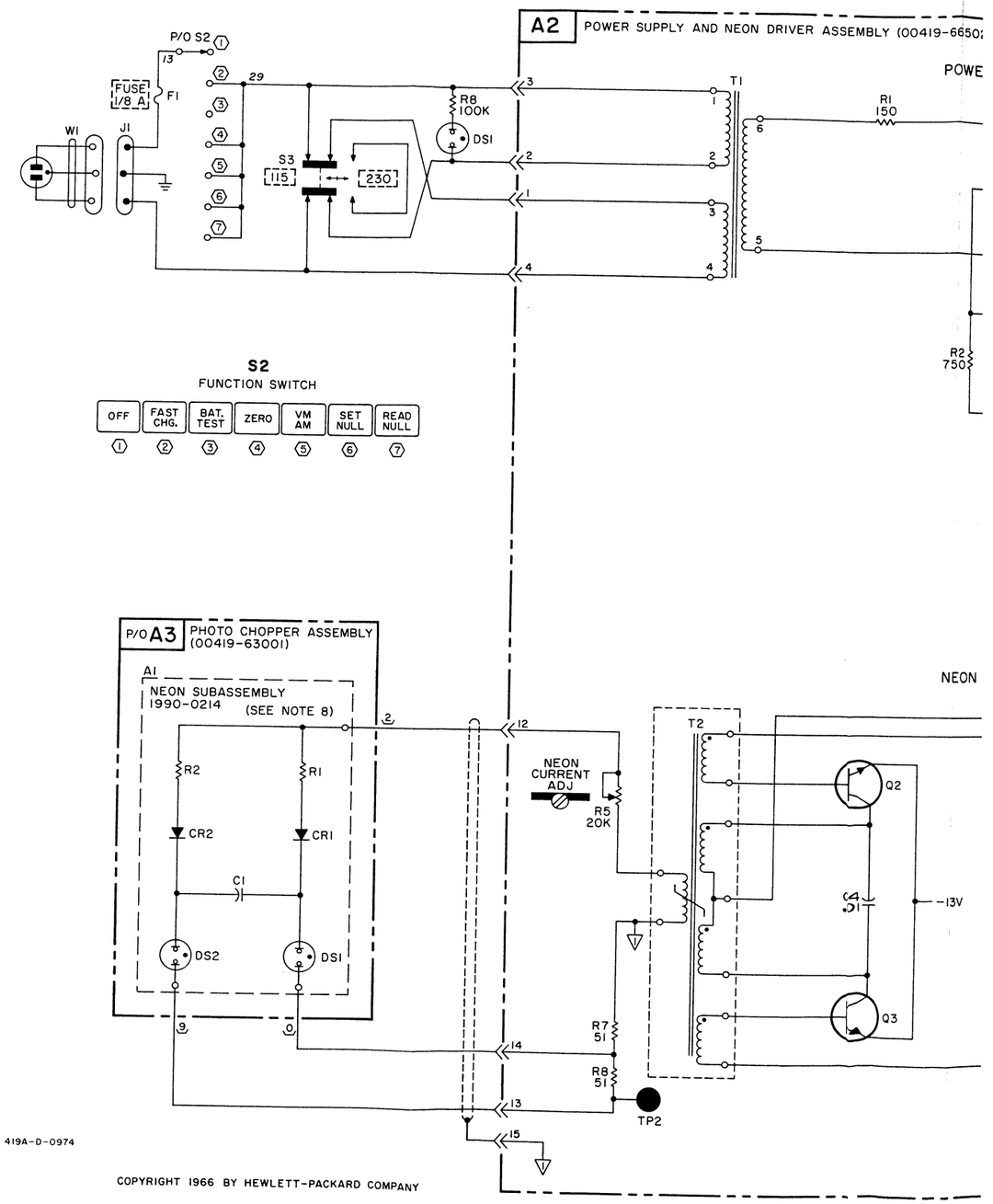
A2
(*hp* Part No. 00419-66502)

NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. ⏚ DENOTES POWER LINE (CHASSIS) GROUND.
   ▽ DENOTES POWER SUPPLY COMMON.
4. ——— — — ——— DENOTES ASSEMBLY.
   — — — — — — — DENOTES SUBASSEMBLY.
   DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
5. DENOTES REAR PANEL MARKING.
6. DENOTES SCREWDRIVER ADJUST.
7. 〈924〉 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g. 〈924〉 = WHITE, RED, YELLOW.)

WIRE COLOR	
0	BLK
1	BRN
2	RED
3	ORN
4	YEL
5	GRN
6	BLU
7	VIO
8	GY
9	WHT

8. INDIVIDUAL COMPONENTS ON A3A1 ARE NOT SEPARATELY REPLACEABLE. SEE PARAGRAPH 5-27.



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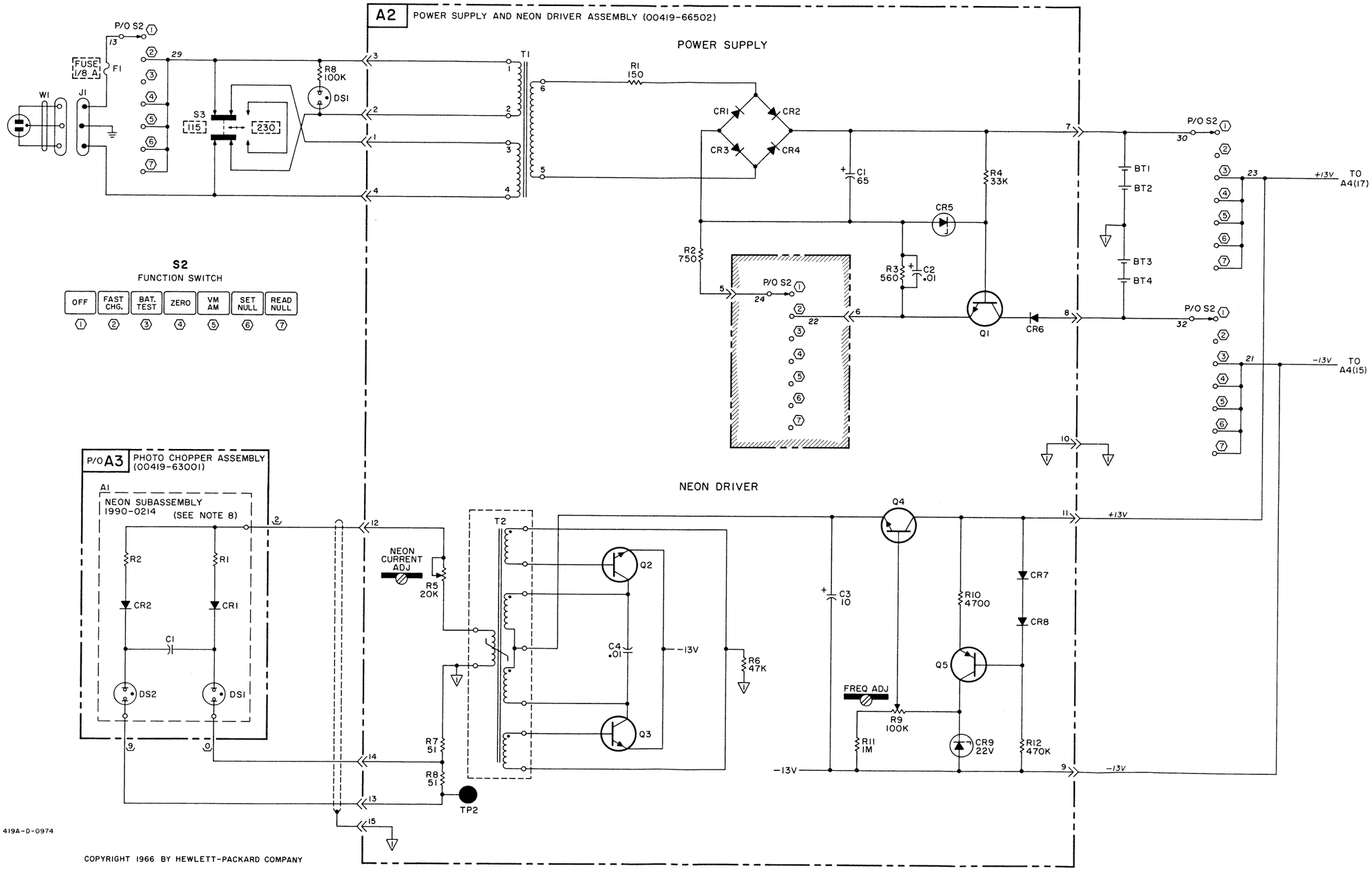

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Figure 6-4. Power Supply and Neon Driver, Schematic and Component Location Diagrams

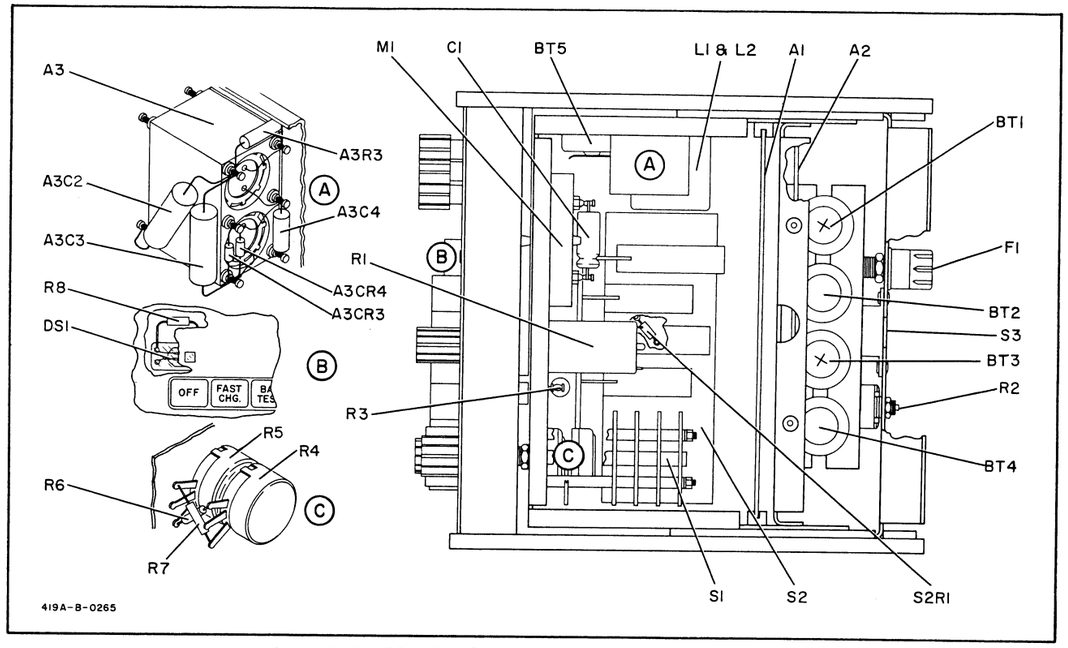
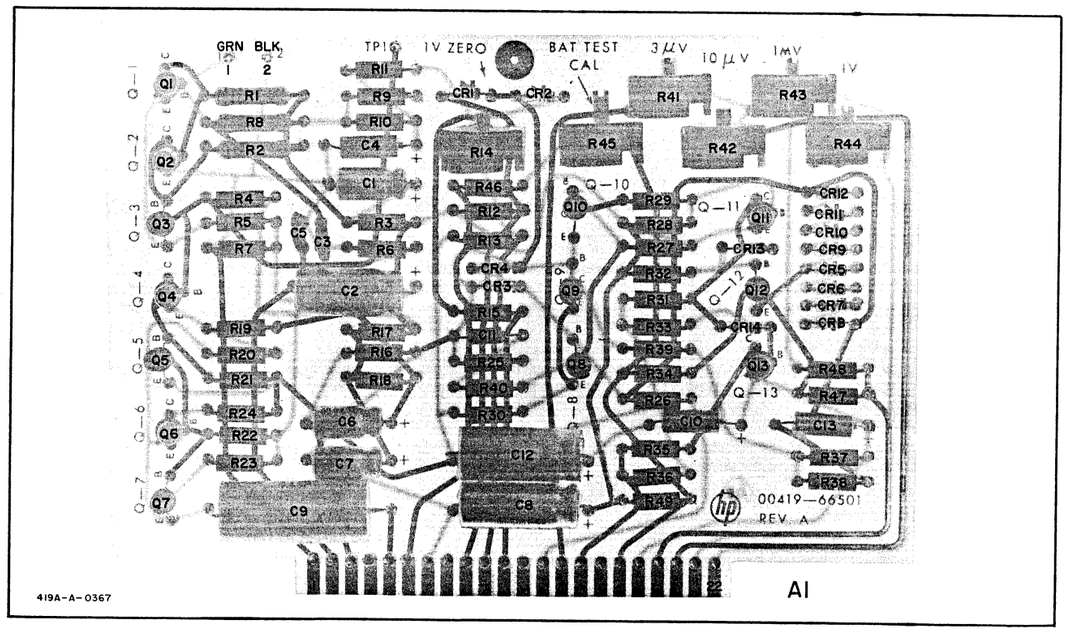


Figure C-1. Model 419A, Component Location Diagram
(Serials Prefixed 514-, 532-, 646-)



Part of Figure C2. A1 Amplifier (00419-66501)
(Serials Prefixed 514-, 532-, 646-)

S2-FUNCTION SWITCH

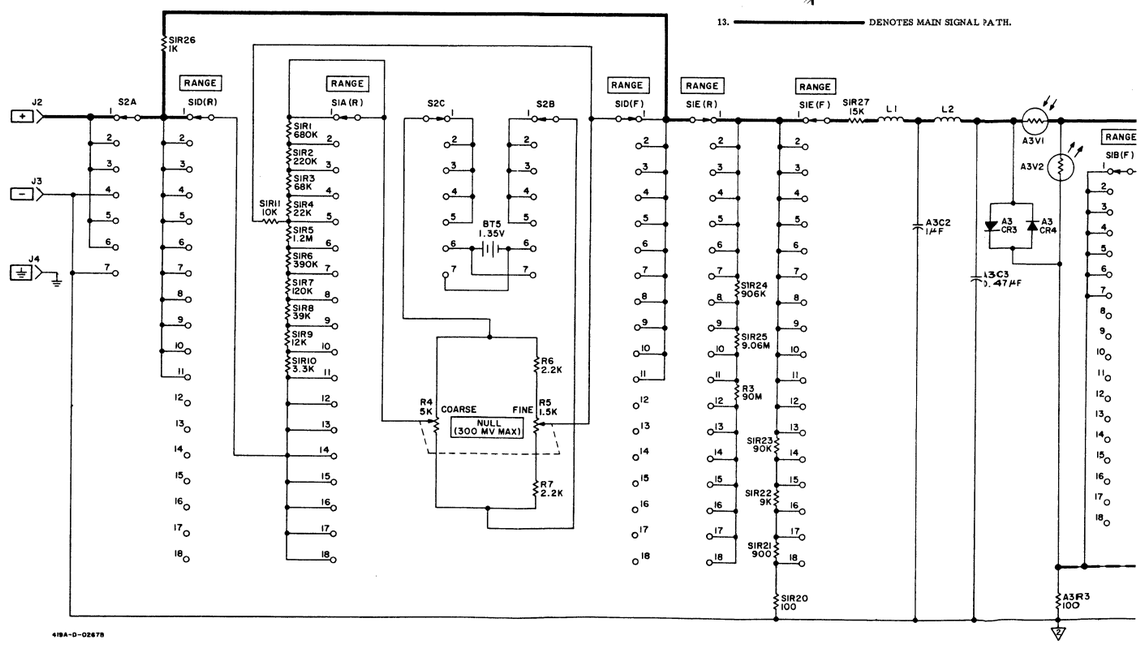
1	2	3	4	5	6	7
OFF	FAST CHG.	BAT. TEST	ZERO	VM	SET NULL	READ NULL

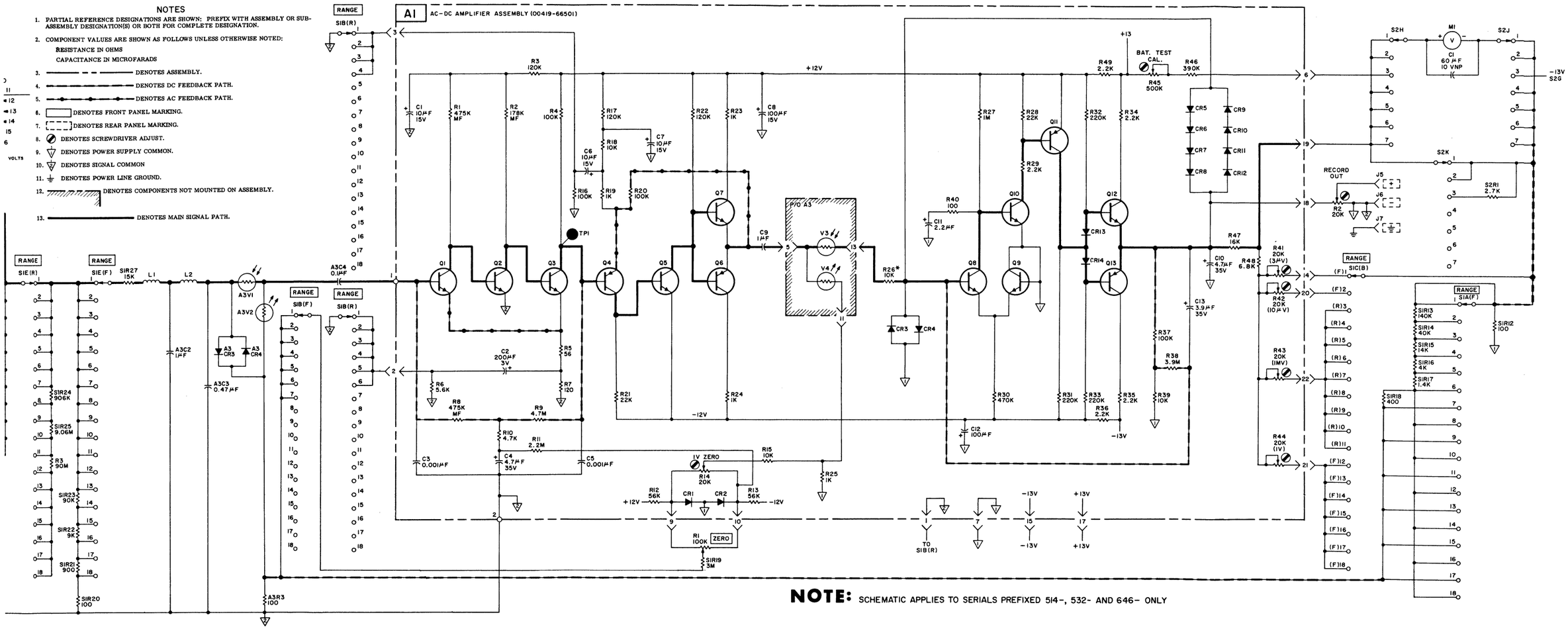
RANGE

MILLIVOLTS: 8, 7, 6, 5, 4, 3, 2, 1 — MICROVOLTS: 300, 100, 30, 10, 3
VOLTS: 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 — 100, 300, 1, 3, 10, 30, 100, 300, 1000

NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUB-ASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. DENOTES ASSEMBLY.
4. DENOTES DC FEEDBACK PATH.
5. DENOTES AC FEEDBACK PATH.
6. DENOTES FRONT PANEL MARKING.
7. DENOTES REAR PANEL MARKING.
8. DENOTES SCREWDRIVER ADJUST.
9. DENOTES POWER SUPPLY COMMON.
10. DENOTES SIGNAL COMMON
11. DENOTES POWER LINE GROUND.
12. DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
13. DENOTES MAIN SIGNAL PATH.





NOTE: SCHEMATIC APPLIES TO SERIALS PREFIXED 514-, 532- AND 646- ONLY

Figure C-2. Amplifier and Amplifier Switching, Schematic and Component Location Diagrams (Serial Prefixed 514-, 532-, 646-)

01779-2